Symposium on Surgical Management of Malignancy of the Colon

Vol. 14 SEPTEMBER, 1943 No. 3

SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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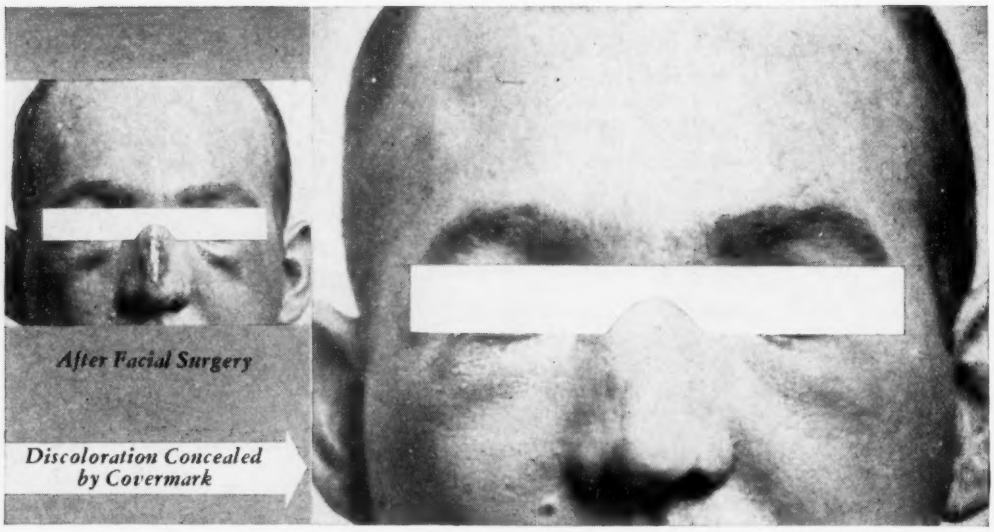

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Suturing the Intestines and Stomach

TO PREVENT leakage of contents, wounds of the intestines or stomach must become air and water tight immediately after suturing. An effective seal is produced and maintained until the regeneration of tissue takes place by the deposition of fibrin between serosal surfaces.

The sutures should, therefore, approximate serosa to serosa and should be so placed as to leave no irregular spaces in which large plugs of fibrin might form.

Closed methods which employ the clamp or cautery to prevent spillage of intestinal contents during suturing should not leave excessive amounts of contused or damaged tissue directly in the suture line. The presence of contused tissue plus even a small number of bacteria, plus sutures which act as foreign bodies, combine to create infection and inflammatory changes which destroy the barrier of fibrin. A persistent leak in the suture line results. Such a leak is a more potent instigator of infection in the peritoneal cavity than the single spillage of a small amount of contents.

The open method of anastomosis avoids the crushing of tissue but causes more bacterial contamination. In either the closed or open method the use of sutures of fine size reduces the amount of foreign body present. Very fine sizes can be used because strength is of secondary importance to the principle of obtaining and maintaining water tightness.

To insure adequate approximation of serosa to serosa at least two layers of sutures are laid. Suturing of the mucosa is almost entirely for the purpose of hemostasis. Whether the sutures employed are interrupted or continuous depends upon the type of material used. Fibrin seals off the interspaces in either case. Unabsorbable sutures tend to move toward the lumen or beneath the serosa. If they are interrupted sutures, those moving toward the lumen fall into it; if continuous, a portion may hang attached for some time. Where this suture pierces the mucosa a small ulcer forms. In the stomach such ulceration may become a chronic non-healing ulcer.

Discussions of fifteen subjects in this series on Suture Use have been published. Reprints (including the above) and a bibliography will be sent on request.

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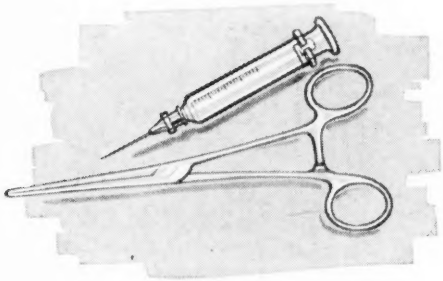

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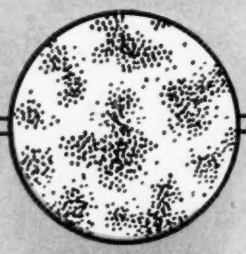
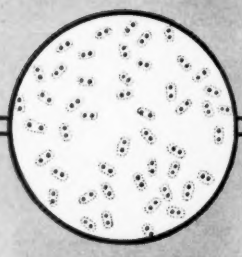


N. catarrhalis
1:84,000*
1:12,000S



K. pneumoniae
1:49,000*
1:8,000S

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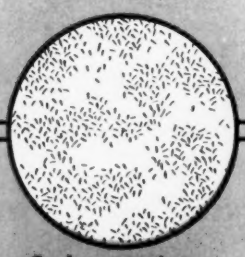

S. dysenteriae
1:68,000*
1:5,000S

Strep. hemolyticus
1:127,500*
1:19,500S

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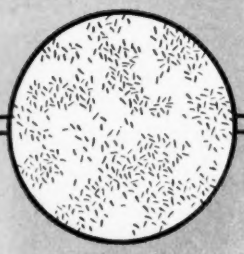
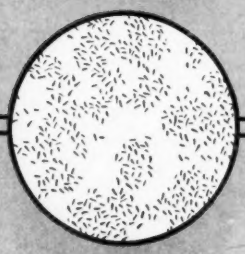
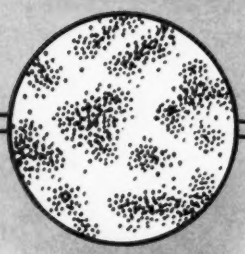
S—Dilution which is germicidal in presence of 10% serum.



C. diphtheriae
1:64,000*
1:14,000S



E. typhosa
1:35,000*
1:3,000S



Staph. aureus
(septicemia)
1:80,000*
1:15,000S

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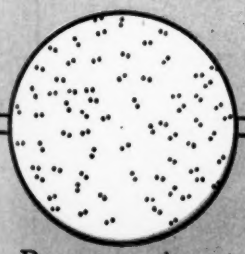
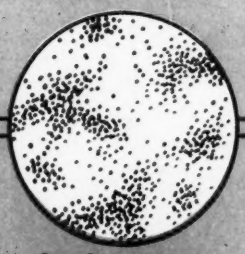
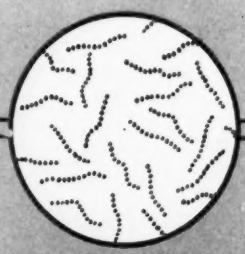


D. pneumoniae
1:120,000*
1:14,000S



Staph. aureus
(osteomyelitis)
1:83,000*
1:13,000S



Strep. viridans
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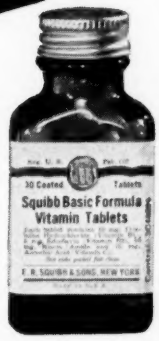

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[1] Spies, T. D.: *M. Clin. North America* 27:273, March 1943.
[2] Jolliffe, N., and Smith, James J.: *M. Clin. North America* 27:567, March 1943.
[3] Spies, T. D.: *J. A. M. A.* 122:497, June 19, 1943.

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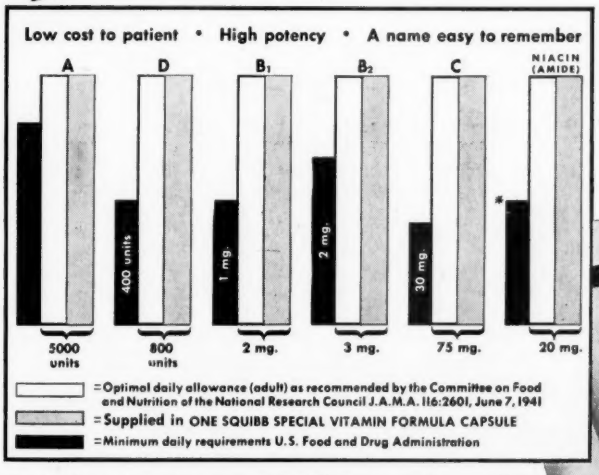
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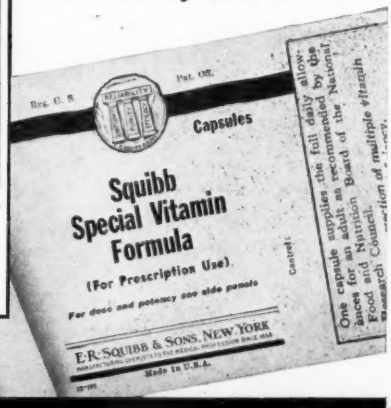

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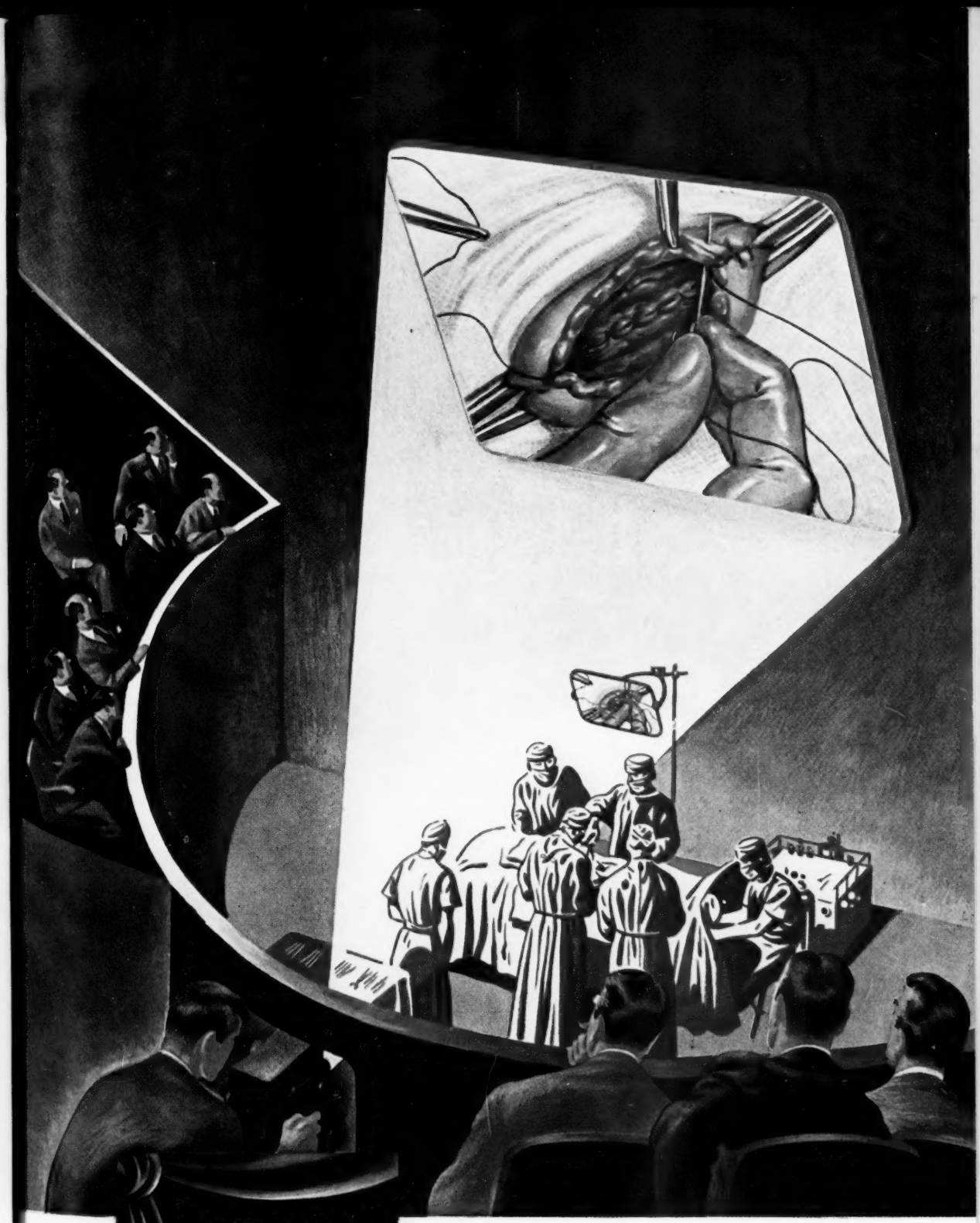

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NO. III

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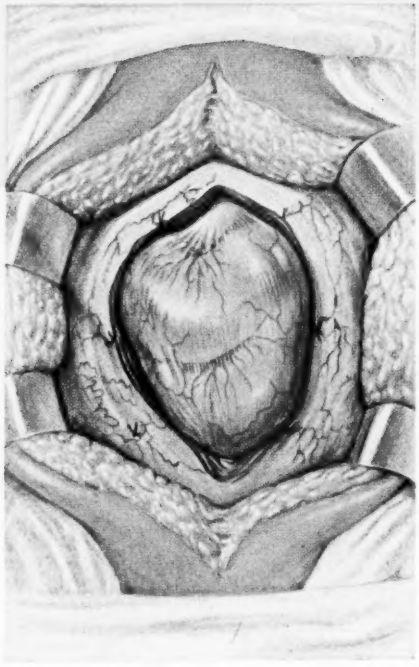
Herniotomy for Ventral Hernia

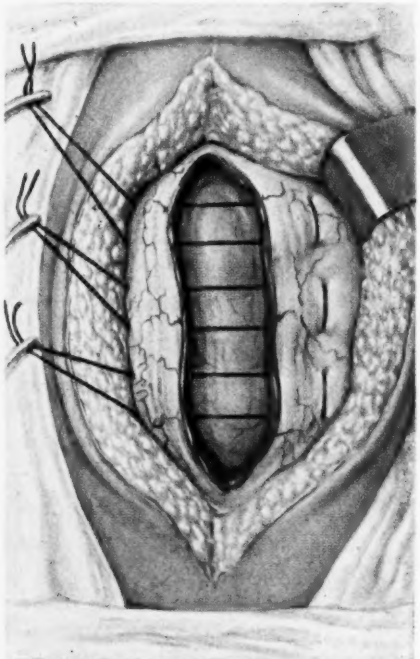
Utilizing Fine Gauge Chromic Catgut and Modification of Edebohl's Technic

This operation demonstrates the manner by which fine gauge chromic catgut may be used to approximate fascia under tension. The placing of heavy gauge temporary tension sutures and secondary incisions make possible thorough and firm approximation by fine gauge chromic sutures.

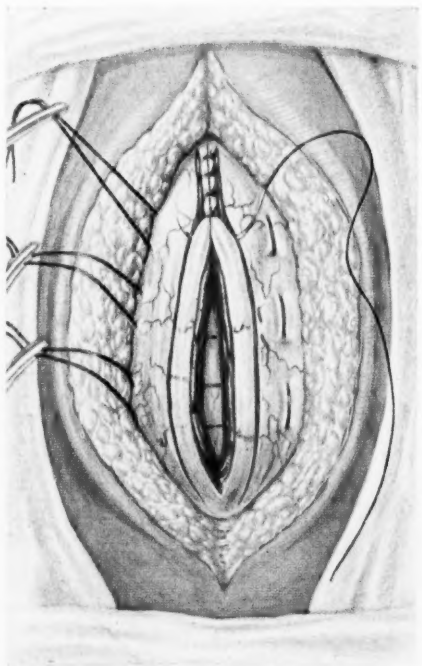
The established principle of the desirability of minimizing tissue reaction is here applied in the use of fine gauge chromic catgut where heavy gauge or non-absorbable suture materials were formerly utilized.



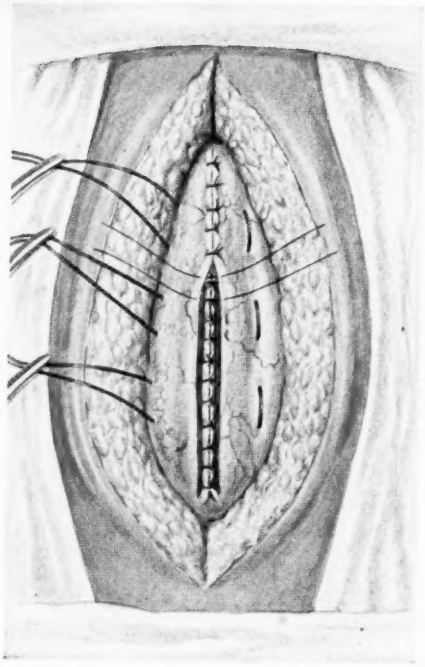
1. The incision has been carried through to the peritoneum. Bleeders have been ligated with Size 000 Medium Chromic Catgut. Note extent of fascial defect.



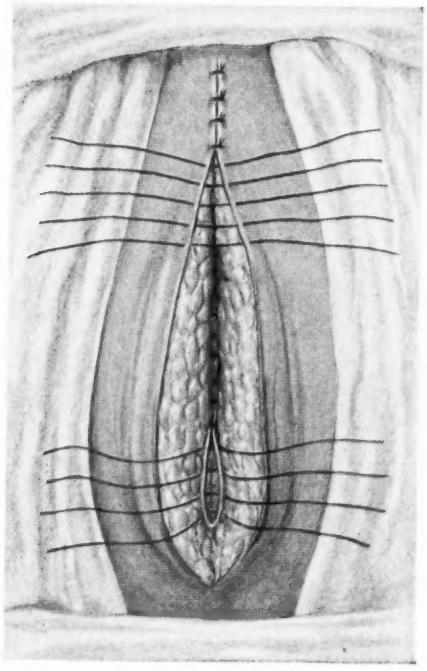
2. Wide area of lateral fascia has been exposed. Three mattress sutures of Size 3 Chromic Catgut or heavy silk have been placed to provide temporary tension.



3. Two longitudinal fascial incisions have been made. The fascia is drawn together by tension applied to temporary sutures and a row of interrupted Size 00 Chromic Catgut Sutures placed. Note use of swedged needle to reduce trauma.



4. Initial row of fascial sutures has been completed. Second layer of fascia is now approximated by interrupted Size 00 Chromic Catgut Sutures.



5. Herniotomy completed with two layers of fascia approximated by interrupted fine gauge chromic sutures. Temporary tension sutures have been removed. Skin closure by interrupted black silk.

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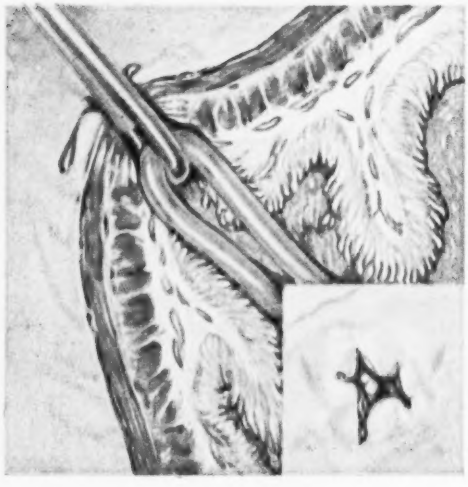
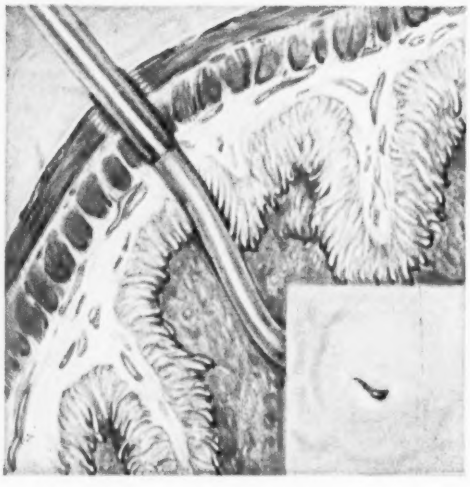


EYED NEEDLE

The eyed needle does greater injury to tissue because it pulls a looped suture in its wake.



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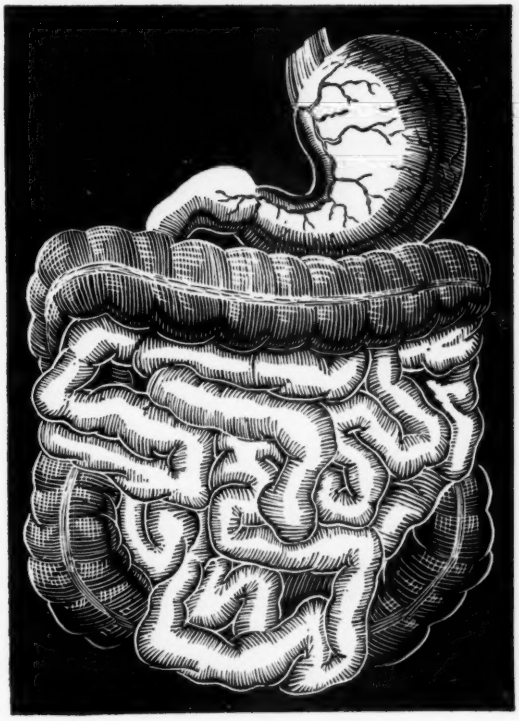

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SURGERY

VOL. 14 SEPTEMBER, 1943 NO. 3

Original Communications

Symposium on Surgical Management of Malignancy of the Colon

SURGERY OF THE TERMINAL ILEUM, CECUM, AND RIGHT COLON

ALLEN O. WHIPPLE, M.D., NEW YORK, N. Y.

(From the Department of Surgery, Columbia-Presbyterian Medical Center, New York, N. Y.)

THE scope and radical character of abdominal surgery, especially in the field of adequate cancer removal, has been greatly extended in the past few years. Several factors are responsible for this advance, among them a better understanding of the importance and the means of maintaining fluid, electrolyte and protein balance, the prevention and treatment of shock by plasma and whole blood transfusion before, during, and after operation, and the control of infection by means of the bacteriostatic sulfonamide drugs. Examples of these very radical procedures are the removal of cancers of the cardia and fundus of the stomach by abdominothoracic resection, or by total gastrectomies, and pancreaticoduodenectomies for cancer of the ampullary region, common duct, and pancreas.

However, in resections of the gastrointestinal tract there are certain fundamental principles that have always determined the kindly healing of the sutured intestine and the peritoneum. It is wise to remember these principles in these days of indiscriminate administration of the sulfonamide drugs locally and systemically. The first of these principles is the maintenance of an adequate blood supply to the zone of anastomosis by careful preservation of the blood vessels in the mesentery supplying that zone. Second, the placing of an accurate seromuscular or seroserous suture to provide an adequate apposition of peritoneum on either side of the suture line. This can be accomplished most certainly with a fine silk suture on a fine needle, using a Lembert or Cushing type

Received for publication, April 26, 1943.

TABLE I

RADICAL COLON OPERATIONS
(1933 TO 1942)

ILEOCOLECTOMIES			RESECTIONS						RANKIN						MIKULICZ					
YEAR AND			LEFT COLON			TRANSVERSE			LEFT COLON			TRANSVERSE			LEFT COLON			TRANSVERSE		
CASES	P.O. DEATHS		CASES	P.O. DEATHS		CASES	P.O. DEATHS		CASES	P.O. DEATHS		CASES	P.O. DEATHS		CASES	P.O. DEATHS		CASES	P.O. DEATHS	
	NO.	%		NO.	%		NO.	%		NO.	%					NO.	%		NO.	%
Cancer																				
(1933-1937) 38	8	21	36	8	22.2	9	3	33.3	16	5	31.5	2	0		10	2	20	4	1	25
(1938-1942) 57	7	12.3	75	6	8	14	2	14.3	14	1	7.1	4	0		12	5	41.7	1	0	
(1933-1942) 95	15	15.8	111	14	12.6	23	5	21.7	30	6	20	6	0		22	7	31.8	5	1	20
Other Diseases																				
(1933-1937) 22	2	9.1	14	1	7.1	2	0		1	1		0			0			0		
(1938-1942) 29	4	13.8	14	2	14.3	4	2	50	2	0		0			1	0		0		
(1933-1942) 51	6	11.8	28	3	10.7	6	2	33	3	1	33.3	0			1	0		0		
Total (Cancer and Other Diseases)																				
146	21	14.4	139	17	12.2	29	7	24.1	33	7	21.2	6	0		23	7	30.4	5	1	20

TABLE II

MILLER-ABBOTT INTUBATION
ILEOCOLECTOMIES
1938 TO 1942*

ILEOCOLECTOMIES	NO.	P.O. DEATHS	MORTALITY %	WITH M.-A. TUBE		WITHOUT M.-A. TUBE	
				CASES	P.O. DEATHS	CASES	P.O. DEATHS
Cancer	57	7	12.3	41	4	16	3
Other diseases	29	4	13.8	18	1	11	3
Total	86	11	12.8	59	5 (8.5%)	27	6 (22.2%)

Postoperative deaths with the Miller-Abbott Tube:

1. Patient did well with tube in stomach; died 7 days after the tube was removed of general peritonitis. (Other.)
2. Patient died of pneumonia; tube removed 24 hours before death, after colostomy was opened.
3. Tube well down and functioning well; Levine tube necessary.
4. Peritonitis, auricular fibrillation. Patient died 19 days postoperatively; first intubation successful, second intubation 15 days postoperatively unsuccessful.
5. Patient died of embolus when getting up the first time.

*Of 86 ileocolectomies, 59 or 68.6 per cent of the patients had the Miller-Abbott intubation prior to operation. In all but five of these, the tube passed beyond the stomach.

of stitch through peritoneum and submucosal layers. This is far more important than clumsy attempts at suturing the crushed mucosae. In fact, in the many techniques described for so-called aseptic anastomosis, the mucosal stitch is never used, and reliance is placed solely on the seromuscular mattress sutures. Third, and most important, is to prevent tension on the suture line with its accompanying tissue necrosis, by keeping the proximal segment of bowel empty of gas and fecal content. If the bowel proximal to the anastomosis is empty, if the blood supply to the zone of anastomosis is adequate, and if the peritoneal fusion of the anastomotic line has been accomplished, healing will always progress satisfactorily and drug therapy will not be necessary, unless gross contamination has occurred or unless other indications for drainage are present.

These principles have long been recognized by thoughtful and intelligent surgeons, and the maintenance of a collapsed proximal loop has been accomplished in the past by making an enterostomy proximal to the anastomosis, usually by means of a rubber tube or catheter, using the Witzel technique. In resections of the left colon a cecostomy is indicated for the same reason, and if obstruction has been present, the cecostomy should always be done a week or more before the resection.

Until recently these principles were at times difficult to carry out, especially in the cases where obstruction had resulted in long-standing distention and hypertrophy of the proximal loop. This was one of the chief reasons why side-to-side instead of end-to-end or end-to-side anastomosis was advocated, because in these patients the distended proximal bowel made it mandatory to use the side-to-side stoma. An enterostomy which was frequently done as a safety valve, to reduce tension on the suture line, provided one more chance of contamination and leak-

TABLE III

RESECTIONS OF LEFT COLON

CARCINOMA OF COLON

1933 TO 1942

YEARS	CASES	P.O. DEATHS	MORTALITY (%)
1933 - 1937	36	8	22.2
1938 - 1942	75	6	8
Total	111	14	12.6

In addition to the resections, the following operations were also performed in this group:

41* preliminary cecostomies (4 P.O. deaths)
22 accompanying cecostomies (2 P.O. deaths)
2 subsequent cecostomies (0 P.O. deaths)
4 preliminary colostomies (0 P.O. deaths)
13 accompanying colostomies (2 P.O. deaths)
2 preliminary appendicostomies (0 P.O. deaths)
5 accompanying appendicostomies (2 P.O. deaths)

*One of these was performed at another hospital.

Average postoperative hospital days of the survivors in this group; 40.06 days per patient (3,886 postoperative days for 97 survivors).

TABLE IV

RESECTIONS OF LEFT COLON

OTHER DISEASES EXCLUSIVE OF CANCER OF COLON

1933 TO 1942

YEARS	CASES	P.O. DEATHS	MORTALITY (%)
1933 - 1937	14	1	7.1
1938 - 1942	14	2	14.3
Total	28	3	10.7

DISEASE	RESECTIONS	P.O. DEATHS
Diverticulitis	6	3
Redundant colon	3	0
Ulcerative colitis	2	0
Megacolon	2	0
Intussusception	2	0
Cancer of rectum	2	0
Stricture	1	0
Fibromyoma	1	0
Endometrioma	1	0
Tuberculosis	1	0
Prolapsing colostomy	1	0
Fistula	1	0
Regional ileitis	1	0
Polyposis	1	0
Ileus	1	0
Volvulus	1	0
Lipoma	1	0
Total	28	3

In addition to the resections, the following operations were also performed in this group:

4 preliminary cecostomies (1 P.O. death)
8 accompanying cecostomies (0 P.O. death)
1 preliminary colostomy (0 P.O. death)
5 accompanying colostomies (1 P.O. death)

Average postoperative hospital days of the survivors in this group; 56 days per patient (1,350 postoperative days for 25 survivors).

TABLE V

RANKIN AND MIKULICZ PROCEDURES
CANCER AND OTHER DISEASES OF THE COLON
(EXCLUSIVE OF TRANSVERSE)
1933 TO 1942

	1933-1937		1938-1942		1933-1942	
	CASES	P.O. DEATHS	CASES	P.O. DEATHS	CASES	P.O. DEATHS
Rankin:						
Cancer	16	5 (31.5%)	14	1 (7.1%)	30	6 (20.0%)
Other diseases	1	1	2	0	3	1 (33.3%)
Total	17	6 (35.3%)	16	1 (6.25%)	33	7 (21.2%)
Mikulicz:						
Cancer	10	2 (20%)	12	5 (41.7%)	22	7 (31.8%)
Other diseases	0		1	0	1	0
Total	10	2 (20%)	13	5 (38.5%)	23	7 (30.4%)

In addition to the above procedures the following operations were also performed:

Rankin:
15 preliminary cecostomies (5 P.O. deaths)
1 accompanying enterostomy (1 P.O. death)
Mikulicz:
10 preliminary cecostomies (2 P.O. deaths)
2 accompanying cecostomies (1 P.O. death)

Average postoperative hospital days of the survivors in, Rankin type, 46.08 days (1,198 postoperative days for 26 survivors); Mikulicz, 48.75 days (780 postoperative days for 16 survivors).

TABLE VI

TRANSVERSE COLON
RADICAL OPERATIONS
CANCER OF COLON

	RESECTIONS		RANKIN		MIKULICZ	
	CASES	P.O. DEATHS	CASES	P.O. DEATHS	CASES	P.O. DEATHS
1933-1937	9	3 (33.3%)	2	0	4	1 (25%)
1938-1942	14	2 (14.3%)	4	0	1	0
Total	23	5 (21.7%)	6	0	5	1 (20%)
			OTHER DISEASES			
1933-1942	6	2 (33.3%)	0		0	
Total	29	7 (24.1%)				

In addition to the above procedures the following operations were also performed:
Resections:
4 preliminary cecostomies (2 P.O. deaths)
9 accompanying cecostomies (1 P.O. death)
2 accompanying appendicostomies (0 P.O. death)
3 accompanying colostomies (1 P.O. death)
Rankin:
3 preliminary cecostomies (0 P.O. death)
Mikulicz:
1 preliminary cecostomy (0 P.O. death)

Average postoperative hospital days of the survivors in resections, 43.45 days (956 postoperative days for 22 survivors); Rankin, 44.5 days (267 postoperative days for 6 survivors); Mikulicz, 60.25 days (241 postoperative days for 4 survivors).

TABLE VII

ILEOCOLECTOMIES
1933-1942

	1933-1937		1938-1942		1933-1942	
	CASES	P.O. DEATHS	CASES	P.O. DEATHS	CASES	P.O. DEATHS
Carcinoma of colon	38	8 (21%)	57	7 (12.3%)	95	15 (15.8)
Other diseases (see below)	22	2 (9.1%)	29	4 (13.8%)	51	6 (11.8)
Total	60	10 (16.7%)	86	11 (12.8%)	146	21 (14.4)

OTHER DISEASES

	1933-1937		1938-1942		1933-1942	
	CASES	P.O. DEATHS	CASES	P.O. DEATHS	CASES	P.O. DEATHS
Regional ileitis	9	0	14	1	23	1
Ulcerative colitis	3	0	2	1	5	1
Diverticulitis	2	0	0		2	0
Tuberculosis	4	1	2	0	6	1
Intussusception	1	0	1	0	2	0
Gangrene	1	1	2	1	3	2
Adenomatosis	2	0	0		2	0
Ileus	0		2	1	2	1
Fistula	0		3	0	3	0
Ulcer of cecum	0		1	0	1	0
Visceroptosis	0		1	0	1	0
Cancer of kidney	0		1	0	1	0
Total	22	2	29	4	51	6

Average postoperative days of the survivors in this group; 37.88 days (4,735 postoperative days for 125 survivors).

age, had to be done at the end of a difficult procedure, and very often did not work satisfactorily after operation. Furthermore, the presence of a distended bowel with the accompanying edema of the cancerous lesion in the presence of obstruction convinced many able surgeons that a two-stage operation for cancer of the cecum and ascending colon was necessary, using a side-to-side ileocolostomy as a first stage operation, to be followed later by the excision of the growth. This required two anesthesias, two operations, and in many instances the second stage was either refused because of a stormy first stage or because the patient delayed until the growth had metastasized or extended far beyond the site found at the first procedure.

Our strikingly favorable results in decompressing the small intestine in cases of inflammatory ileus and ileus due to bands and adhesions by the use of the Miller-Abbott tube, soon after its demonstration by the authors of this epoch-making discovery, led us to use it as a preoperative measure in resections of the terminal ileum, cecum, and right colon. The immediate improvement in the morbidity and mortality of our operations for carcinoma of the cecum, ascending colon, and hepatic flexure and for such lesions as regional enteritis, especially in terminal ileitis with resection of the cecum and right colon, with end-to-side ileocolostomy in all these procedures, has convinced us that preoperative and postoperative decompression of the proximal intestine, by means of the Miller-Abbott tube, is the method of choice and far superior to

an enterostomy done at the time of resection. Furthermore, the two-stage procedure was done away with in favor of the one-stage operation.

In our own experience we have found that with the proximal bowel decompressed, the hazard of spillage and contamination is eliminated and the anastomosis by the open method, with careful protection of the wound and remaining peritoneum and accurate suture technique, is as safe as the so-called aseptic methods, and more certain of giving an adequate stoma and avoiding subsequent leakage.

The tables summarize the results and are self-explanatory. Attention is called to Table II to compare the mortality in cases in which the intestinal intubation was done and in cases where it was not done.

THE BLOOD SUPPLY OF THE LARGE BOWEL WITH REFERENCE TO RESECTION

ALBERT O. SINGLETON, M.D., GALVESTON, TEXAS
(From the Department of Surgery, Medical Branch, University of Texas)

THE large bowel lends itself to surgical procedures quite conveniently, provided the surgeon familiarizes himself with essential anatomical facts. This knowledge pertains particularly to its blood supply. The blood supply to the stomach is so abundant that one may here do almost any type of resection or plastic procedure with perfect confidence of sufficient vascularity of the remaining tissues for certain healing. This is generally true with the small intestine, but certainly not with the large intestine.

The arrangement of the arteries to the colon has been cleverly demonstrated by Jamieson and Dobson, Rubesch, Drummond, Steward and Rankin, and others. The injection of the main arteries with an opaque medium and the use of x-ray film have been the chief methods employed. These investigations have been stimulated by the failures in colon surgery due to an insufficient blood supply to the part of the bowel remaining after resection of certain segments for carcinoma and other diseases.

It will be noted in Fig. 1 that lymph glands are very numerous along the mesenteric border in the large intestine, and that lymphatic channels follow closely the blood vessels to the origin of the mesenteric arteries at the root of the mesenteries. The extent of lymphatic removal is often limited because to remove them means sacrificing blood vessels that are essential to the vitality of bowel which must be left. The necessity of wide removal of lymphatics is no less in cancer of the colon than elsewhere in the body. In one's zeal for extensive removal of lymphatic glands, such previously mentioned large vascular trunks may be ligated, endangering the circulation to the ileum at times, and in longer lengths of colon than anticipated, with immediate grave danger to the patient.

The blood supply to the large bowel is from three major sources (Fig. 1):

1. The superior mesenteric artery
2. The inferior mesenteric artery
3. The internal iliac branches: (1) middle hemorrhoidal, (2) inferior hemorrhoidal, and (3) pudic

Received for publication, July 12, 1943.

A better understanding of the colon circulation may be had if we divide its arterial arrangement into three parts:

1. The main arterial trunks and branches
2. The marginal artery (of Drummond) with its vascular loops and vasa recta
3. The blood vessels within the bowel wall

These divisions may apply to the entire larger bowel, except the rectum, where the same arrangement of the circulation does not exist.

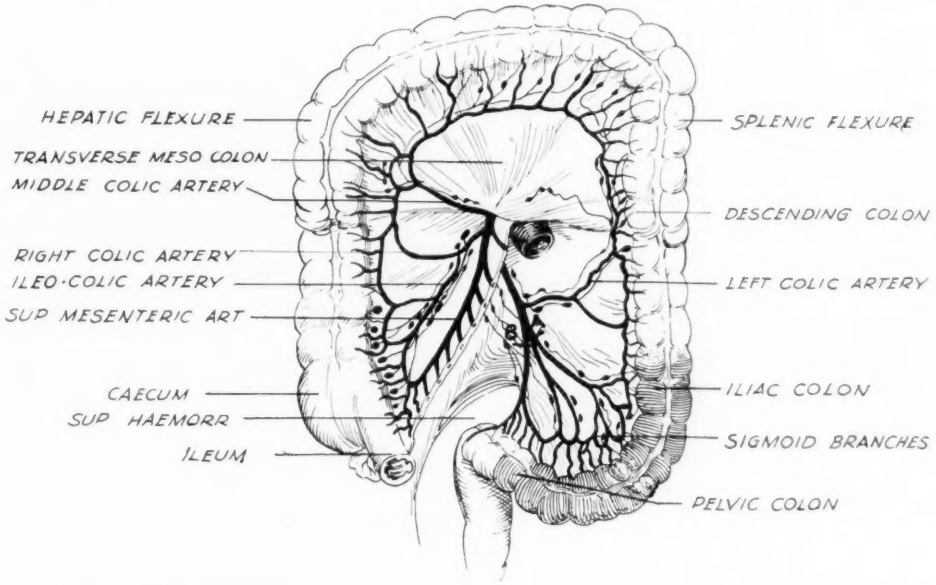

Fig. 1.—Diagram showing blood supply and the lymphatic distribution to the colon.

1. *The Main Arterial Trunks and Branches.*—The superior mesenteric through its right colic and middle colic branches, supplies the ascending colon, the hepatic flexure, and transverse colon. The remaining part of the colon and the upper half of the rectum are supplied by the left colic and sigmoid branches of the inferior mesenteric artery. One of these branches, the terminal branch of the inferior mesenteric, is the superior hemorrhoidal. The remainder of the rectum and the anus are supplied by the middle hemorrhoid from the internal iliac and the inferior hemorrhoidal from the internal pudic branch of the internal iliac. It is evident that the rectal circulation is much more adequate than the other sections of the large bowel (Fig. 2).

Abnormalities of the blood vessels of the colon are present occasionally. The superior mesenteric artery may be double, and it may supply the whole intestine from the duodenum to the end of the rectum, the inferior mesenteric artery being absent.

Again the superior mesenteric artery may give branches to the hepatic, renal, and middle colic arteries; also its left colic branch may

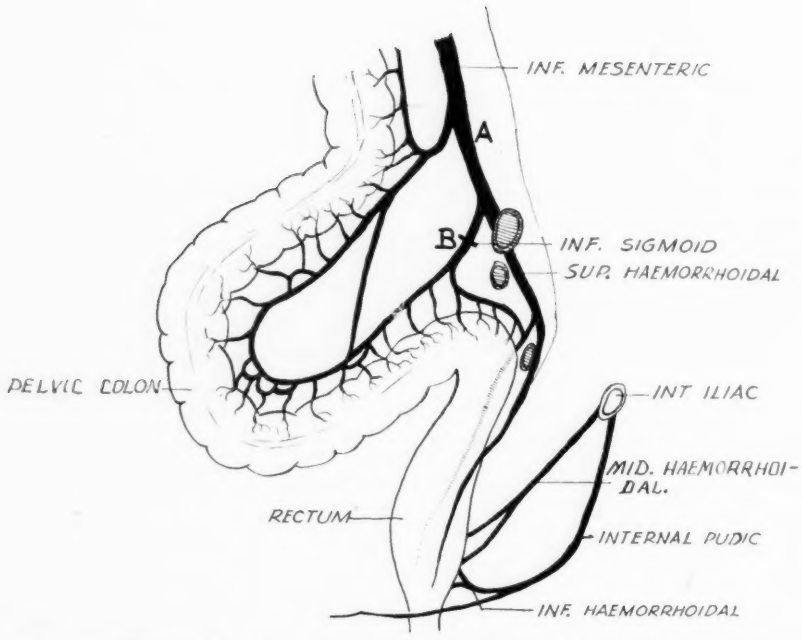

Fig. 2.—Illustration of the blood supply to the rectum which is more richly supplied with blood than the other parts of the large bowel.

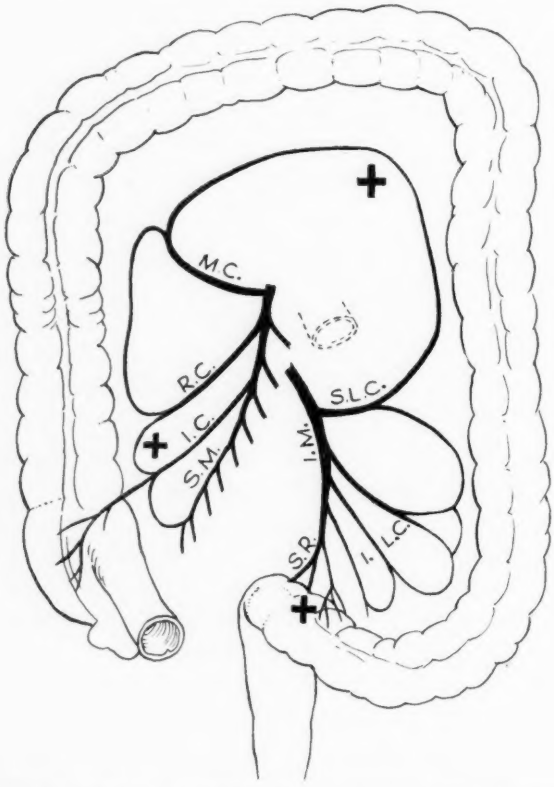

Fig. 3.—X denotes three weak points in the marginal anastomoses: (1) between the ileocolic and right colic. (2) between middle colic and superior left colic. (3) between the inferior left colic and superior rectal. (From Grant, *Method of Anatomy*, Williams and Wilkins Company.)

not anastomose with the middle colic artery, as is found in some rodents.

The *right colic artery* is quite inconstant. It originates from the superior mesenteric in 40 per cent of cases, from the middle colic in 30 per cent, from the ileocolic in 12 per cent, and in 18 per cent it is absent (Rankin and Graham). The middle colic artery is also irregular. It supplies the greater part of the circulation to the splenic flexure of the colon and a still greater part of the circulation of this area when the left colic is absent or not well developed. A failure of anastomosis of the middle colic and left colic arteries, which occurs in 5 per cent of cases (Grant), results in a break in the continuous flow of blood through the marginal arteries of the colon near its mesenteric border from the cecum through the sigmoid segment (Fig. 3).

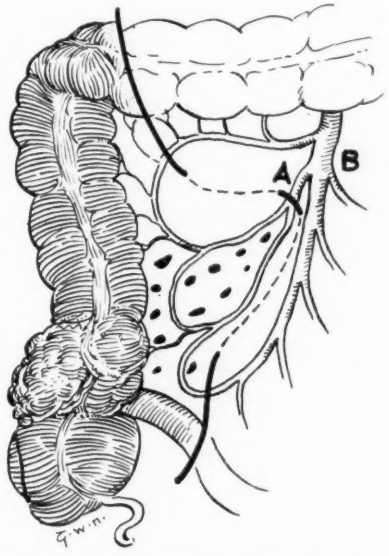

Fig. 4.—The area of resection of the cecum with ligation of ileocolic artery near the superior mesenteric at *A*. *B*, Main branch of superior mesenteric which may be ligated inadvertedly when an attempt is made to remove the lymphatic glands and would result in death of a large part of the small intestine.

A review of the circulation of the colon, by examining the illustrations, will make it evident that care should be taken in the placing of ligatures when resecting certain parts of the large bowel in order that the bowel to be left will not be endangered by inadequate blood supply. In the very fat mesocolon one may have difficulty in seeing the large blood vessels, but ordinarily by lifting the bowel up with the light on the opposite side they may be seen.

For example, in resection of the cecum the ileocolic artery should be ligated at *A* which denies several inches of the terminal ileum of its circulation but this part of the ileum is to be removed. The circulation of a large part of the small intestine will be impaired if (in going too high) the main trunk of the superior mesenteric is occluded at *B*.

Again, if in resection of the cecum and right half of the transverse colon (Fig. 5) the *middle colic artery* is tied near its origin from the superior mesenteric at *A*, the middle and left half of the transverse colon may be devitalized, and this may necessitate the removal of almost all the transverse colon, or even the splenic flexure whose circulation may be so impaired due to an inconstant left colic artery, and it would not survive after anastomosis. To avoid devitalizing the middle portion of the colon, this artery should be carefully preserved when doing a gastrointestinal anastomosis through the mesocolon. We know of such accidents having occurred with disastrous results. Generally such an injury to the circulation of the colon by transmesenteric anastomosis is due to injury to the marginal colic artery or its vasa brevia, but occasionally the circulation of the left half of the colon and splenic flexure is dependent upon the middle colic artery where the left colic is poorly developed. (33 per cent of cases, according to Grant.)

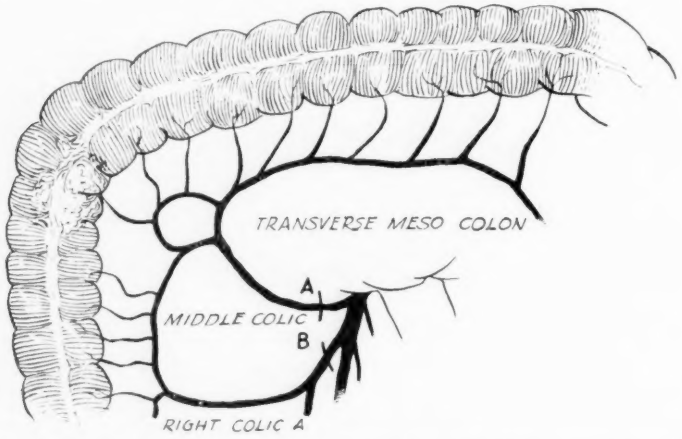

Fig. 5.—In a certain number of cases where the left colic artery does not anastomose too freely with the middle colic past the splenic flexure, resection of the cecum and hepatic flexure may result in extensive devitalizing of the transverse colon when the arteries are tied at *A* and *B*.

In resection of the sigmoid flexure (Figs. 1 and 2) one may impair seriously the circulation of the distal segment of the colon by ligating the inferior mesenteric artery at *A*, or the right sigmoid branch at *B*. This may make anastomosis of the proximal and distal ends of the remaining colon impossible.

In the resection of the *rectum* for cancer (Fig. 6), in order that adequate bowel is removed to include the high lymphatics, the inferior mesenteric artery should be ligated at *A*. This naturally results in devitalizing the sigmoid fairly high up, necessitating the removal of the lower half. But this is not a disadvantage because a more satisfactory sigmoid colostomy results if the terminal loop is short, and with such a short sigmoid terminus, function seems to be better and prolapse of the mucosa is much less likely to occur.

2. *The Marginal Artery (of Drummond) With Its Vascular Loops and Vasa Recta* (Fig. 7).—The superior mesenteric system is continuous with that of the inferior mesenteric through the junction of the middle colic branch of the former with the left colic branch of the latter. Drummond injected under pressure the inferior mesenteric ar-

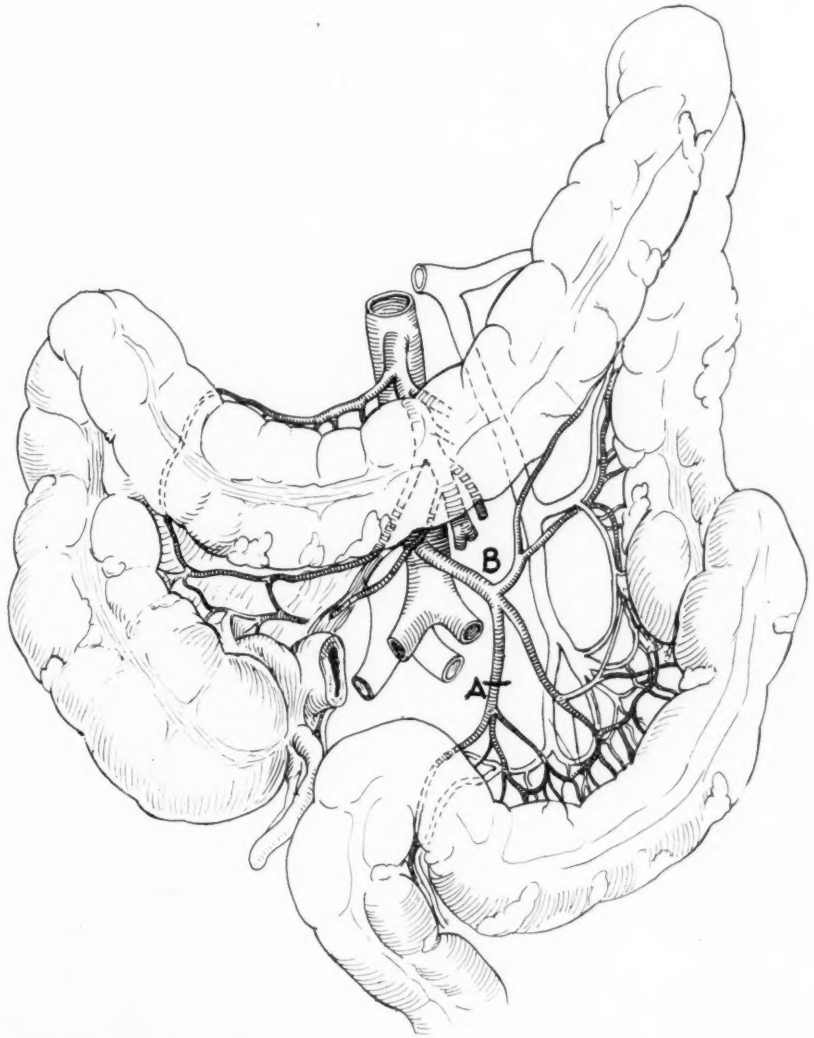

Fig. 6.—Position of ligatures for resection of the rectum. *A*, Ligation of the superior hemorrhoidal and inferior sigmoid allows wide excision and still preserves the circulation to the upper half of the sigmoid. *B*, If ligature is placed on inferior mesenteric above the origin of the left colic the circulation will be lost too high up on the sigmoid for satisfactory colostomy.

tery, and the injection passed up through the left colic filling the branches of the superior mesenteric. Rubesch, by injecting through the superior mesenteric artery, pressed the fluid into the inferior mesenteric in the reverse direction. Though the circulation through Drummon's arch from the superior and inferior mesenteric arch is a con-

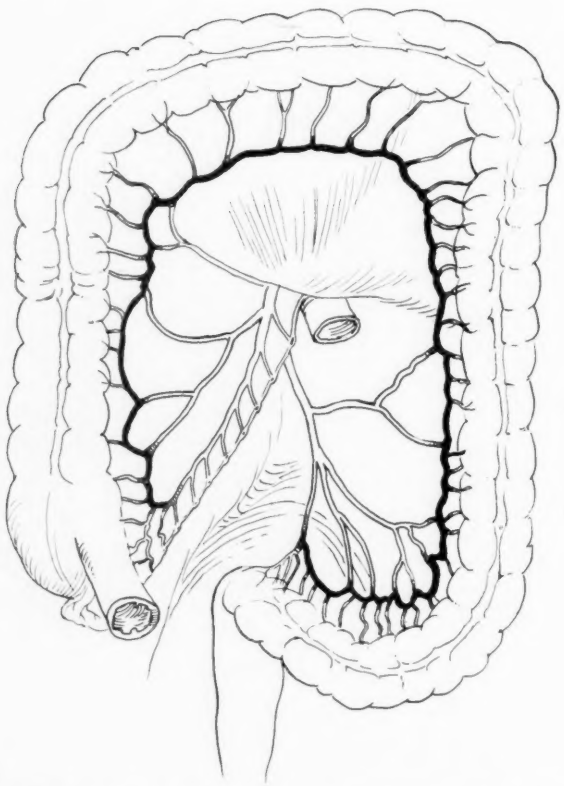

Fig. 7.—Branches coming off the mesenteric arteries form a continuous vessel within the circle of the colon a short distance from its margin throughout the length of the colon, through which the circulation from the two mesenterics communicate. Marginal artery of Drummond.

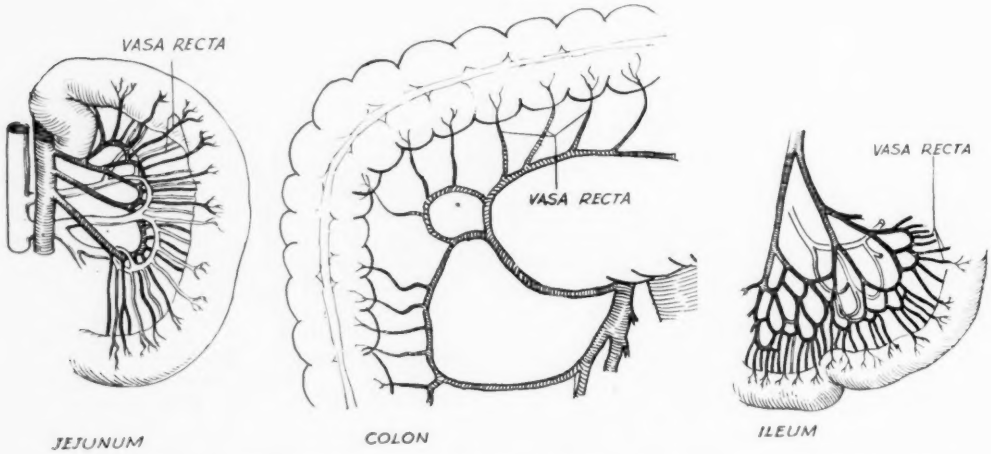

Fig. 8.—Illustration of the circulation near the bowel wall showing arcades and vasa recta to the jejunum, ileum, and colon. It is evident that the circulation to the jejunum is not so rich as to the ileum and that the colon circulation is much less adequate than other parts of the intestine. There are decidedly fewer vasa recta going to the large bowel and their anastomosis is very inadequate. Danger of devitalizing the bowel and freeing its mesentery for end-to-end anastomosis is very great as compared with the same procedure on the small bowel.

tinuous one, the anastomosis is not so free that one vessel may be occluded and the colon survive depending only upon the circulation from the other one.

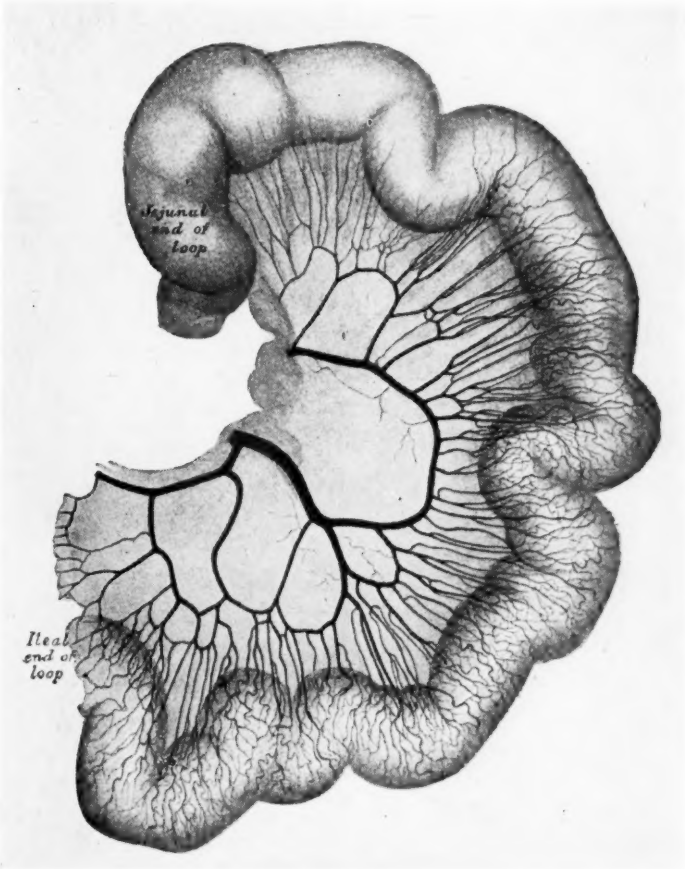

Fig. 9.—Loop of small intestine showing distribution of intestinal arteries. (From a preparation by Mr. Hamilton Drummond.) The arteries and arterioles are numerous in the bowel wall and anastomoses are very free in the ileum and less free in the jejunum. (From Gray, *Anatomy*, Ed. 24, Philadelphia, 1924, Lea & Febiger.)

It is also well to call attention to the arrangement of the circulation nearer the bowel wall. Branches coming off the mesenteric arteries from the center of the abdomen form a continuous vessel which within the circle of the colon extends its entire length forming an arch (called the marginal arch) which is at a fairly constant distance from the mesenteric border. At certain places the arch may be broken into several arcades. From this arch and its arcades, vasa recta spring and pursue a straight course to enter the mesenteric border of the gut without anastomosing with one another. The anastomosis between these vasa recta in the bowel wall is not very free, and in operations which result in division and anastomosis of the intestine, injury to these

border vessels must be avoided. The number of arcades and vasa recta are less numerous in the jejunum than in the ileum and still less numerous in the colon (Fig. 8).

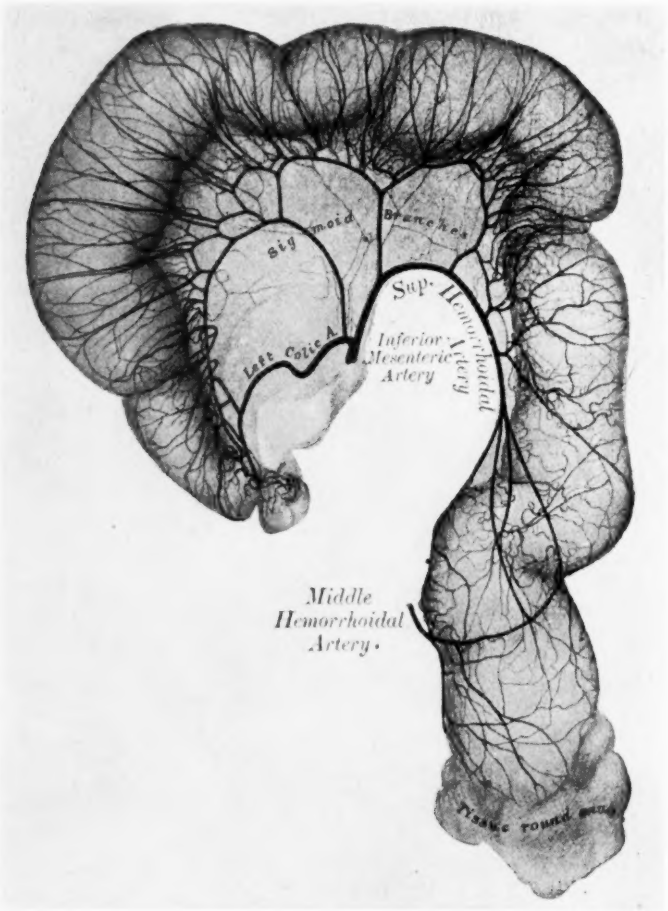

Fig. 10.—Sigmoid colon and rectum, showing distribution of branches of inferior mesenteric artery and their anastomoses. (From a preparation by Mr. Hamilton Drummond.) Illustration, by contrast, of the deficiency of the circulation in the colon. The arteries and arterioles are much fewer and farther apart and the anastomosis is much less frequent. (From Gray, *Anatomy*, Ed. 24, Philadelphia, 1924, Lea & Febiger.)

3. *The Blood Vessels Within the Bowel Wall.*—The anastomosis of the vessels within the bowel wall is not a free one as stated before, and particularly so in the colon. If we examine Fig. 9 it will be seen that the number of arteries and arterioles in the jejunum are less numerous than in the ileum, and the anastomosis is correspondingly different. In Fig. 10 we can contrast the circulation in the wall of the colon with that in the wall of the small intestine. It will be seen clearly that, not only are there fewer arteries in the colonic wall but they are much further apart. Also, the anastomosis between these vessels is much less

frequent in the large bowel and there is correspondingly, a much poorer blood supply.

If we examine in more detail it will be seen that the terminal arteries as they approach the bowel are made up of short and long branches, the former entering the wall directly, while the long branches pass subserously directly toward the antimesenteric border and penetrate to the submucous layers much farther from the mesenteric border and on to the end in very fine fragments at the antimesenteric areas with scant anastomoses with the branches from the other side (Fig. 11). Therefore, the antimesenteric area of the colon, which is between the taenia, is poorly supplied with blood but does receive some from terminal vessels on either side.

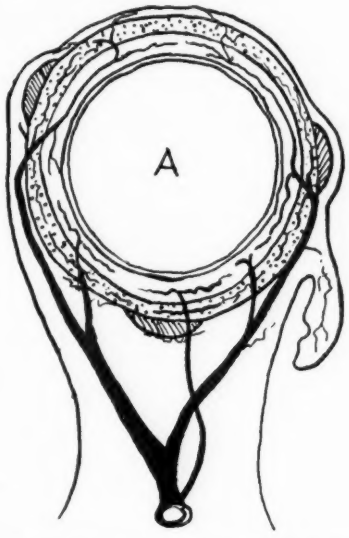

Fig. 11.—The arteries as they approach the bowel are made up of long and short branches, the former entering the wall directly while the long branches pass subserously toward the antimesenteric border and end in very fine fragments with scant anastomoses to the branches from the opposite side. (From Rankin and Graham, *Cancer of the Colon and Rectum*, Springfield, Charles C Thomas, publisher.)

Based upon these anatomical facts it is suggested that:

1. In opening the bowel in a temporary colostomy the incision should be made at the antimesenteric border between the taenia and the long axis of the bowel.

2. In doing ileocolostomy with the end-to-side, or side-to-side anastomosis, this area of the colon should be the site of union.

3. Because of the poor anastomosis between the vasa recta, a minimum amount of freeing of the mesentery from the bowel should be done when making an end-to-end anastomosis of the colon following resection.

4. Because of the direction of the terminal vessels and their lack of anastomosis, when resecting the colon to be followed by end-to-end

suture, the clamps should be placed across the bowel at a slight angle so that the circulation of the free border may be maintained (Fig. 12).

Appendices epiploicae: Because of the unreliability of the circulation of the colon, even the epiploicae are not to be overlooked by the surgeon. These fatty appendages may be useful to tack over suture

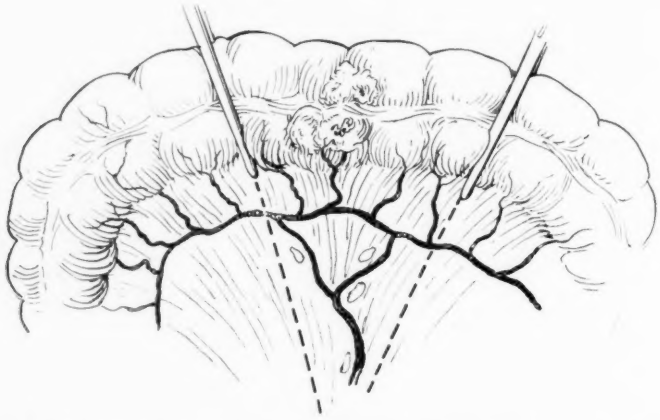

Fig. 12.—Because of the vertical course of the vasa recta over the bowel wall, it is advisable when resecting the colon and doing an end-to-end anastomosis, that the clamps be placed at an angle so that the circulation on the antimesenteric border will not have been interfered with.

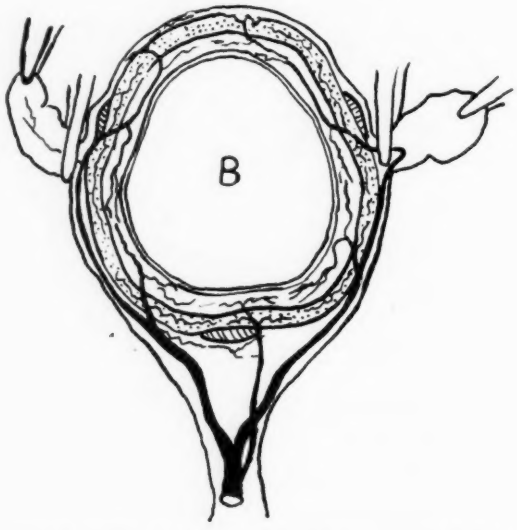

Fig. 13.—The correct (left) and incorrect (right) method for clamping epiploic appendages. (From Rankin and Graham, *Cancer of the Colon and Rectum*, Springfield, Charles C Thomas, publisher.)

lines for reinforcement by encouraging healing and preventing leaking. At times they may be in the way and interfere seriously with good apposition of serous surfaces of the colon in anastomosis. It is common knowledge that free hemorrhage occurs when one of these is cut off the bowel with frequently some blanching of the wall on the anti-

mesenteric side of the appendage. Rankin calls attention to the arrangement of their circulation which indicates that preservation of the epiploicae is advisable, but when it is found necessary to remove one, the artery passing through its base should be saved (Fig. 13).

The omentum (Fig. 14): The omentum may have a part in colon surgery. Its part cannot be said to be of major importance; on the other hand it may be very useful. Its power of rapidly becoming adherent to peritoneal surface, sealing over areas of bowel with questionable circulation, and reinforcing suture lines is well known. It establishes vascular connections with the tissues to which it becomes attached in a very short time, and may save bowel wall from necrosis

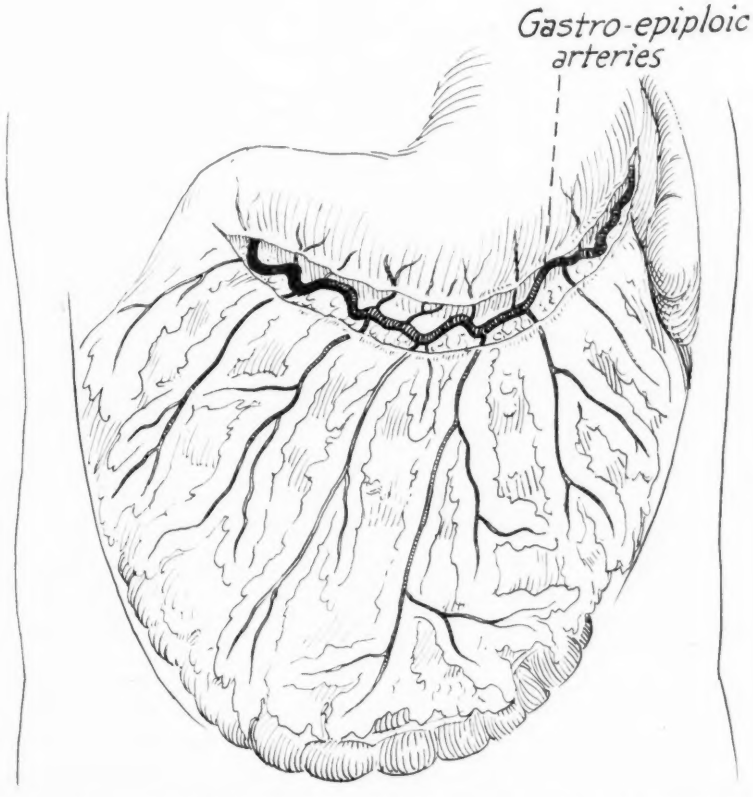

Fig. 14.—The omentum with its rich circulation may be used with advantage about anastomosis of the colon because of its power of adhering and rapidly supplying circulation to the sutured area in the colon.

in this manner. The blood supply to the omentum is very rich and entirely from the gastric vessels. Embryologically it identifies itself with the stomach and receives its circulation from the gastroepiploic arteries, and though it becomes attached to the transverse colon and upper surface of the mesocolon in embryonic life, strange to say practically no blood flows from the colon to the omentum except in small vessels through the phrenocolic ligament. Because of its rich blood

supply and its power to attach itself to the traumatized bowel and supply it with blood, it should be used to reinforce suture lines in the colon.

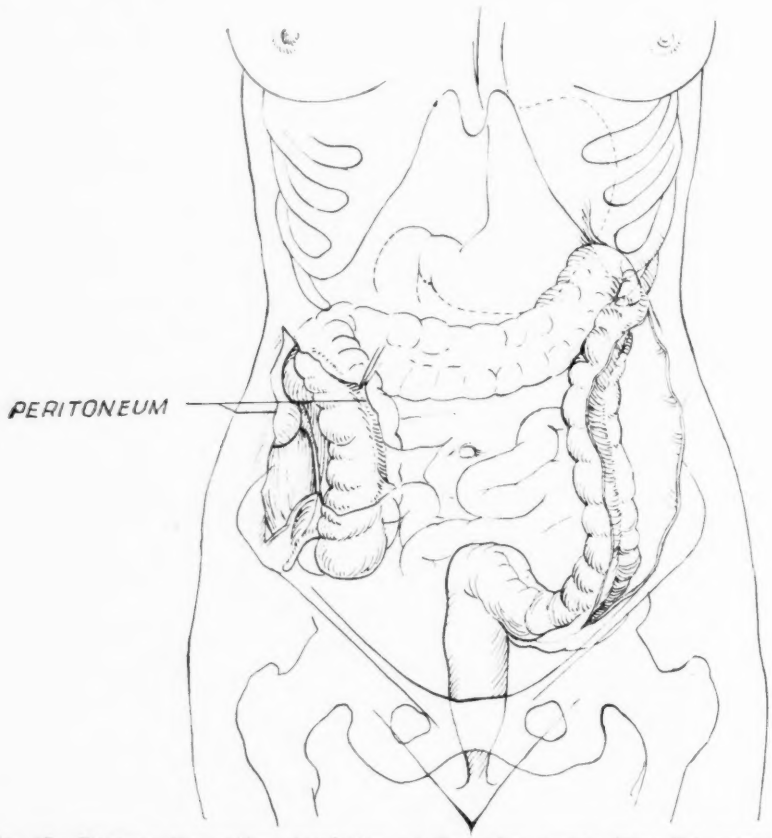

Fig. 15.—Because the entire circulation of the colon comes from the mesenteric vessels and radiates from the center of the abdomen to the colon it is possible to incise the lateral peritoneal reflection of the cecum and ascending colon on the right and the descending colon and sigmoid on the left without encountering blood vessels, permitting the free delivery of these parts of the bowel out of the wound in the process of excision.

Although as mentioned previously there are disadvantages in the arrangement of the blood supply of the colon from the standpoint of surgery, still there are some favorable facts in its arrangement. In surveying the blood supply to the large bowel, one should be aware of the fact that all its arteries come from the center of the rectangle formed by the colon and radiate from the center to the periphery. This means that the peritoneal reflection of the bowel on the lateral aspect of both the ascending and descending colon may be freely incised without encountering blood vessels. This permits the delivery of the cecum and ascending colon and the hepatic flexure through the wound and out of the abdomen, facilitating easy resection (Fig. 15). Similarly, on the left side at the splenic flexure and the descending colon, severing the lateral peritoneum is done with the same freedom

from important blood vessels, freeing this portion of the colon, allowing the same easy manipulation and greatly simplifying the operation. The splenocolic ligament at the splenic flexure may contain a small vessel which requires tying, but the hepatic flexure attachment may be severed with impunity.

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CONSIDERATION OF ELECTIVE SURGICAL PROCEDURES IN VARIOUS SEGMENTS OF THE COLON

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(From the Cleveland Clinic)

ACTIVE interest in the surgical management of malignancy of the colon and rectum of the past twenty years is evidenced by the large number of contributions to the literature. Anatomy, of course, has not changed, surgeons have not suddenly become expert, but improvement in surgical technique and the application of physiologic principles have increased the scope of operability, lowered the mortality, decreased morbidity, and increased curability. Allied branches of medicine, such as x-ray, have contributed materially to the earlier recognition of malignancy, and the renewed interest of pathologists has led to a better understanding of its spread; this knowledge has been very helpful to the surgeon in his surgical approach. Early diagnosis, insistence on good preoperative preparation, improved anesthesia, and chemotherapy have all contributed to making the problem a much more hopeful one than formerly. From descriptions of operations performed, radical procedures seem to be the vogue, and curbed by the necessity of saving one kidney, a part of the stomach, or a part of the bladder, from an anatomical standpoint the suregon has almost reached the limit in the eradication of malignant disease of the colon and rectum. Further benefits must come from earlier diagnosis, which obviously is lagging far behind improvement in surgical technique. Change in bowel habit or the presence of bleeding must be considered as being due to malignancy until disproved, if we are to make further progress.

From the standpoint of surgical technique there are admittedly many different ways of accomplishing a certain operation in a certain segment of the colon. The one fundamental prerequisite, however, is to do as extensive and as radical an operation as possible. Whether this is done by the closed or open method, by the one-stage or two-stage method, or by any other technique makes little difference provided the surgeon can show that his results from the standpoint of mortality and morbidity are equal to those of other techniques. Perfecting one technique is better than trying every new procedure that is introduced unless one has an abundance of material. It is advisable, of course, not to take an attitude of laissez faire and to be facile enough to adopt something new if it is proved to be distinctly better.

While one may prefer a certain standard procedure in certain segments of the colon, the findings at operation may necessitate a variation in technique. Obstruction, subacute perforation, or fixation must alter

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the course of even the staunchest advocate of the one-stage procedure. Graded procedures are necessary for utmost safety in this limited group of cases. In the final analysis the main controversy in surgery of the colon revolves around (1) the one-stage or two-stage procedure, and (2) the open and aseptic or closed method of anastomosis. There has been an active and healthy dispute regarding these principles, but certainly one can anticipate a better understanding of the methods involved, and the issues are not so unrelated as they would seem. Improvements along one line or another may cause a change of method. For instance, sulfanilamide may change a two-stage operator into a one-stage advocate, or the use of the Rankin clamp may cause an advocate of the open method to use the closed method. Broadly speaking, I am inclined to agree with Rives[1] when he says, "Less depends on the method used than the manner of its execution." A cursory review of mortality figures in recent years shows a disparity of 10 to 25 per cent for the same operation. This disparity is probably due to the manner of execution. Stone and McLanahan[2], in reporting 166 resections from the cecum to the rectum, show a preference for one-stage operations and closed anastomosis. Out of the entire series there were only eleven two-stage procedures. The overall mortality was an excellent one of 13.8 per cent. In cases of open anastomosis the mortality was 26.3 per cent (in nineteen cases), while in the closed anastomosis it was 11.2 per cent (in seventy-one cases). The reader may reflect that they have had four times as much experience with the latter, and that may play a part. I have always believed that peritonitis depends not so much on soiling as on leakage at the suture line or secondary to a bad wound infection, and since this can happen in the two-stage anastomotic procedure as well as the one-stage I prefer the one-stage procedure.

In all statistics a higher mortality is quoted for palliative anastomosis and resection than for completed cases. This probably demonstrates the importance of vitamin and plasma protein deficiency in infection and wound healing. The patient with advanced malignancy is probably lacking in both of these essentials and therefore cannot tolerate a minor procedure. However, cancer is a fatal disease and operative mortality cannot be viewed in the same light as in nonfatal cases. The surgeon must be courageous. His responsibility is to palliate as well as to try to cure. The decision in any individual case rests upon the surgeon's experience, his philosophy regarding malignant disease, the patient, and the lesion.

Lesions in the right colon whether in the cecum, ascending colon, or hepatic flexure are best treated by right colectomy. My preference in this group of cases is the one-stage right colectomy with ileotransverse colostomy with an end-to-side anastomosis over a Rankin clamp. It is applicable to practically all cases. Only the occasional case involves the ileocecal valve causing obstruction, and perforation is uncommon.

Formerly a small catheter was inserted by Witzel's method into the ileum about six or eight inches from the anastomosis to prevent tension on the suture line and to relieve pressure within the bowel. Lately this technique has been changed and the Miller-Abbott tube has been substituted with satisfactory results. However, if the tube is not proved to be in the ileum before operation, the catheter is still used. Because of the frequent difficulty in passing the tube, the intolerance of certain patients to it, and irritation from it which may produce pulmonary complications when necessary for many days, the ileostomy tube may be more satisfactory.

The great advantage of the one-stage over the two-stage procedure is economy in hospitalization and rehabilitation time, yet economy in time cannot be argued against safety. In either case these patients must have a few days of preoperative care in which transfusion is of first importance because so many have a secondary anemia. A review of forty-five unselected cases shows that the average hospitalization period was twenty days. This is considerably less than for the two-stage procedures. The mortality was 13 per cent. One of the greatest difficulties in resection of the right colon, particularly in the very obese patient, is peritonealization of the right gutter. Improperly completed, it will lead to adhesions and obstruction which is a definite factor in mortality. For several years we have obviated this by the use of the modified Mikulicz pack (Figs. 1*A* and 1*B*) described recently[3]. It prevents the small intestine from becoming adherent, and the postoperative convalescence is therefore much smoother. The combination of a well-prepared patient, decompression of the ileum either by Miller-Abbott tube or ileostomy tube, the use of the Mikulicz pack when indicated, the use of steel wire figure-of-eight sutures to prevent infection and disruption will, I feel confident, reduce the mortality considerably in this current series. If the surgeon has not had sufficient experience to be adept in the use of the Rankin clamp he should resort to other procedures. When it is impossible to use it because of immobilization of the colonic segment I do not hesitate to do an open anastomosis which is generally side-to-side.

I have had no experience with the modified Mikulicz operation on the right colon. It has been advocated by Lahey[4] in recent articles. Cattell[5] reports a mortality of 3 per cent by this method in over 100 cases. The objections to it, of course, are the same as for ileostomy in addition to the longer period of hospitalization. However, the discomfort does not last for many weeks and if it lowers the mortality over other operations by another 10 per cent it surely will become the method of choice.

The classical two-stage procedure is the side-to-side anastomosis between the ileum and transverse colon and the resection of the right colon at a later date. The objections are that (1) a person is running the risk of accidental death twice instead of once; (2) the hospital stay is greatly increased; (3) complications such as pneumonia, embolism,

phlebitis, infected wounds, etc. may delay or actually defer indefinitely the completion of the second stage procedure. Therefore, I use it only in cases where there is obstruction or perforation of the growth.

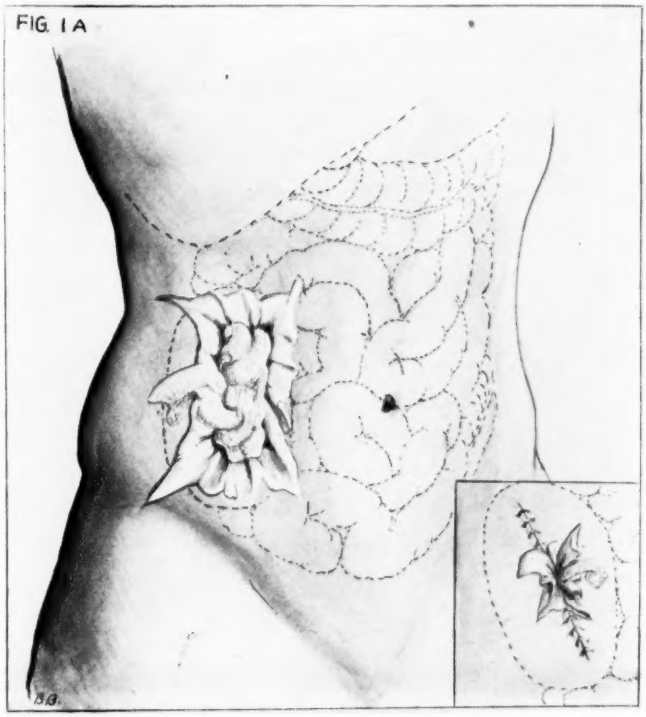

Fig. 1A.—Diagrammatic sketch of pack after closure.

In the transverse colon one has a variety of satisfactory procedures. Ordinarily mobilization is easy, and the blood supply is good. Mayo and Simpson[6] report a mortality of 11.1 per cent in resection and primary anastomosis in contrast to 20 per cent mortality in ninety-five cases of extraperitoneal resection. Stone reports a mortality of 7.1 per cent in fourteen cases by this procedure. In the past it has also been my choice. In my own twenty cases there were two deaths, or a mortality of 10 per cent. In the one-stage procedure with resection, done in the manner of choice to fit the case, I believe it is important to do a complementary tube cecostomy. It is simple to do through a McBurney incision. It will lower mortality and morbidity, and it does not prolong hospital stay, for if the tube is removed on the fifth or sixth day it will be closed by the time the patient is discharged from the hospital. In cases of marked obstruction, which generally is not the rule, the tube cecostomy should be done first under local anesthesia, followed in a week by resection. I thought my own mortality rate could be improved upon and, for that reason, am trying a series of Rankin obstructive resections. I have reason to believe that the mortality will be lower, al-

though sufficient cases have not been done for comparison. It would have to be materially lower to justify the extra ten days in the hospital and a longer convalescence. Most have to be closed secondarily, and this cannot be done until about eight weeks later. During this time the patient is unproductive because in ordinary times his employer will not re-employ him until the job is complete.

If the obstructive resection technique is employed it is better to make the incision through the rectus muscle, right or left, according to the location of the lesion. The application of the spur clamp is safer, and in the closure of the stoma a better abdominal wall will result with less danger of weakness or definite hernia.

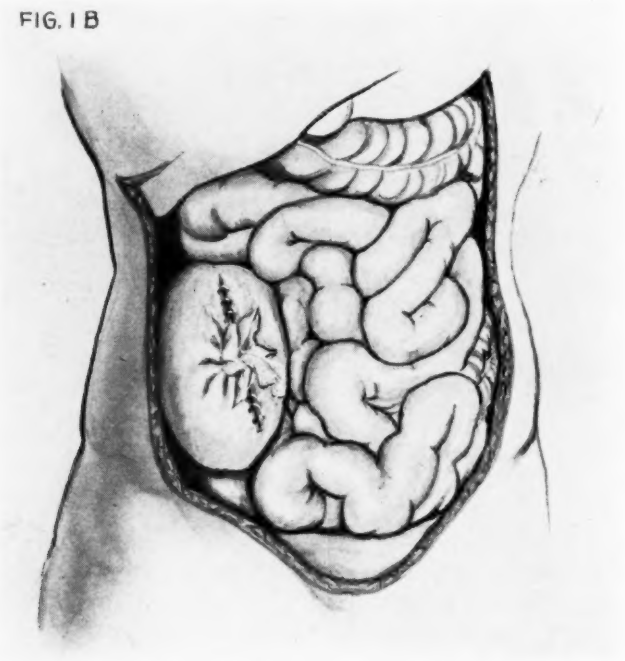

Fig. 1*B*.—Diagrammatic sketch of pack intraabdominally.

A lesion at the splenic flexure presents more difficulty than in any other segment of the colon. It generally lies very high and is frequently adherent to the spleen. In its mobilization the capsule of the spleen will tear and give rise to very troublesome bleeding. In two of our cases the spleen had to be removed before the operation could be proceeded with. In another case a gauze pack had to be placed tightly against it. I believe the obstructive resection is the best procedure here, and a left costal border incision makes it easier than a left rectus incision. In a total of twenty-four cases there were five deaths, a mortality of 20 per cent in all types of operations. An analysis of recent cases, in which the obstructive resection was used with the utilization of a Mikulicz pack in the large cavity which could not be peritonealized,

indicates that the mortality can be lowered to equal that of resections on other segments of the colon. The pack is brought out through a stab wound in the flank.

Previous to 1938, I favored resection of the sigmoid in one-stage proceduce with end-to-end anastomosis and frequently with tube colostomy above the growth or tube cecostomy. The mortality in this group including descending colon and sigmoid in 128 cases was 14 per cent. Even though it compared favorably with other statistics, I felt it could be improved upon. With the use of sulfanilamide, as at present, it probably would have been lowered. I had objected to the Mikulicz type of resection on account of the frequent postoperative hernias, and I had seen many cases of recurrence in the scar, the cause of which was obvious. It seemed to me that the quoted mortality in this operation was also too high if it was designed to do away with the most frequent cause of death, viz., peritonitis from the open operation. Consequently, I started a series of the Rankin modification of obstructive resection. It seemed to me that one could do as radical an operation with this method as with the resection and anastomosis, a thing that the Mikulicz operation did not stress and the thing which caused the local recurrence. We reported this group of cases this year.[7] From January, 1938, to July, 1942, the series totalled seventy-seven cases, sixty-one being in the left colon. The mortality was five cases or 6.5 per cent. This definite drop in mortality seems to justify continuance of the procedure in preference to others. In this group spontaneous closure occurred in eleven cases or 14 per cent. The total hospital stay in this entire group of cases averaged twenty-eight days. This included preoperative treatment in all cases, in ten of which a cecostomy had to be performed for obstruction, and the hospital stay for closure of the colostomy, the latter averaging eight days. It was not necessary to do a second operation for closure in a single case. The technique is described in the article and will not be repeated here. Mayo and Simpson quote a hospital stay of fifty-nine days with this procedure.

As one reads the literature there is no apparent unanimity of opinion as to what constitutes the rectosigmoid. I take it to be the junction between the rectum and the sigmoid, and if the rectum is five inches long then the rectosigmoid should be a small segment of bowel beginning at about the peritoneal reflection and extending proximally for not more than two inches. Most lesions at this point obviously cannot be exteriorized, yet one frequently reads about the Mikulicz operation for rectosigmoidal cancer. As a working basis I consider a lesion whose lower edge borders on the peritoneal reflection, or a segment two inches above it, as rectosigmoid and subject it to the same operation as those listed under carcinoma of the rectum.

One of the most difficult decisions to make is the type of procedure best adapted to a lesion whose lower border is three inches above the peritoneal reflection in an obese patient. Even the most radical sur-

geon does not want to sacrifice the rectum unnecessarily. To save the rectum one must be committed to a higher mortality and morbidity. The choice lies between two procedures: (1) colostomy followed by resection and end-to-end anastomosis, and (2) the anterior resection, or Hartman procedure, of dividing the bowel at a safe margin below the growth, then turning in the rectum and bringing the proximal loop out as a permanent colostomy. The former will carry a higher mortality and a lower curability rate, in my opinion. In the very obese patient and

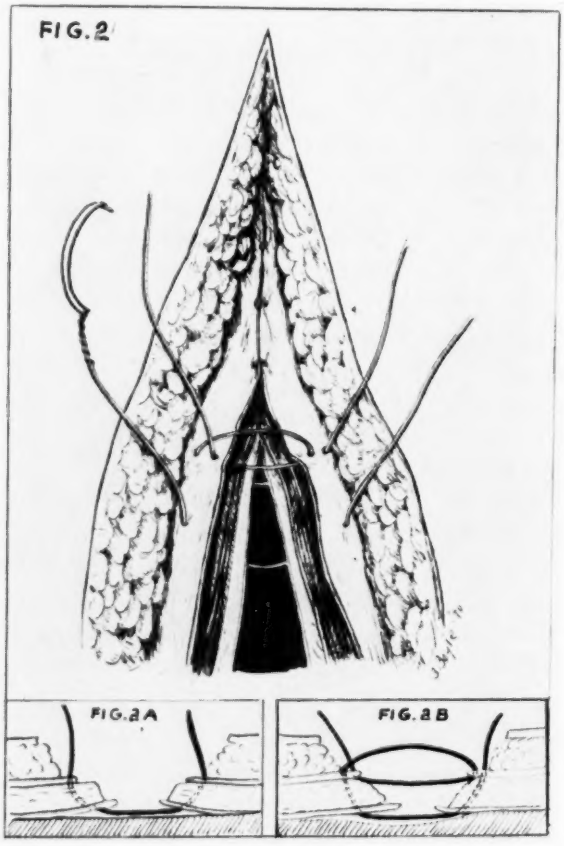

Fig. 2.—The suture passes first through the anterior fascia muscle, peritoneum (Fig. 2*a*) and again through the anterior fascia in the same direction (Fig. 2*b*).

frequently in cases of a very short sigmoid, the operation is mechanically impossible particularly if one is keeping curability as the foremost indication of the operation. The latter is a more radical resection, the mortality will be lower, and the curability higher. In this particular lesion I would base the decision on age of the patient alone. In the young I would do an anastomosis and preserve the continuity of the bowel. In people over 60 years of age I would do the anterior resection and eliminate the two other surgical procedures.

Dixon[8] has been advocating resection and end-to-end suture on lower lesions, even bordering on the peritoneal reflection after a colostomy has been done in preparation. Time only will tell whether the mortality, morbidity, curability, and prolonged hospital stay justify the procedure.

My views upon the choice of surgical procedure for cancer of the rectum have long been known. As I first believed with firm conviction even though with temerity,. I am now more convinced than ever that the procedure of choice for this lesion and those in the rectosigmoid, as I interpret it, is the one-stage abdominoperineal resection, the Miles' operation. It offers the best hope of cure, the lowest mortality and morbidity, and the greatest palliation of all procedures. In a series of over 600 cases the mortality was 7.2 per cent. Since October, 1941, until May 1, 1943, we completed 128 consecutive cases without a single fatality. It must be apparent from this number that bad risks were given a chance as well as good risks. The patients in eight cases had liver involvement at the time of operation. Twenty-five had arteriosclerotic heart disease with hypertension; five had had coronary heart disease; four had diabetes. Twenty-seven had had previous abdominal operation, which, in general, is a complicating factor. The total hospital stay in this entire group averaged twenty-two and one-half days. Only ten had a stay of over thirty days. There were no disruptions, and only two abdominal wounds were infected. Attention has been called to this before[9] and has been attributed to the figure-of-eight alloy steel wire closure (Fig. 2). Elimination of infection reduces mortality and morbidity to a very low percentage which increases the scope of operability. To include those with metastatic lesions will of course decrease the curability rate. That makes little difference. We will make more people comfortable for a longer period of time.

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CARCINOMA OF THE COLON

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CARCINOMA of the colon occurs with sufficient frequency to make it a subject of interest at any time. The increasing awareness of this malady has come about through educational methods affecting both the medical profession and the public. The symptoms of this disease may be insidious to a point of complete hopelessness, but are usually sufficiently characteristic to cause the victim to seek investigation at a curable stage. Not only is the extirpation of the lesion possible in the majority of instances, but the survival rate is high. When one compares the outlook with cancer elsewhere in the body, it is obvious that the colon represents one of the most favorable sites for cure.

The *physician* to whom the patient appeals must exert every effort to make a diagnosis. This responsibility is too often delegated to the roentgenologist. The latter may have no help from the physician or from the patient regarding the symptoms that have initiated the study. This may lead to a negative report, which often has a marked bearing on the ultimate outcome. The patient is entitled to a careful consideration of abdominal discomfort, change in bowel habit, loss of blood from the bowel, fatigability, anorexia, and weight loss. A satisfactory history and a careful physical examination may afford only enough evidence to warrant further study. It is necessary to consider repeated investigations, setting a time-limit interval of one month, and the probability of a better opportunity for a correct deduction if the patient is hospitalized. Only by such methods can one expect to make the diagnosis early. The importance of early diagnosis cannot be overemphasized, since it is directly related to curability. The average delay between onset of symptoms and hospital admission in our clinic was eight months.[1] This is too long, and every effort must be made to decrease it. I am sure that the operability and cure rate will rise tremendously if this interval can be reduced.

The diagnosis of carcinoma of the colon having been established, the *patient* has the right to expect relief from his disorder. This can be brought about only by surgery, which he can further expect will be compatible with life, extirpation of his disease, and the restoration of his health. Although the necessary steps are often disagreeable to a point of feeling that the cure is worse than the disease, the end result

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should warrant cooperative effort on the part of the patient. The outlook, without surgical interference, is hopeless and if this fact could be properly linked with the probability of cure, less would be said concerning associated discomforts. Most of the fear and dread of the entire procedure can be eliminated by a careful explanation to the patient and his family of the program to be undertaken in his behalf.

The *surgeon,* to whom a patient with carcinoma of the colon is referred, has definite responsibilities. In order to fulfill his obligation to the patient, he must evaluate the entire situation with care; the general condition of the patient, his systems, obesity, anemia, and nutritional state must be considered. The time element of preoperative study and preparation will vary but, too often, the patient and his family, by their anxiousness "to get it over," precipitate surgical interference before the optimum time for surgery has arrived. According to the site of the lesion and the amount of obstruction present, the manner of handling the situation to the best interests of the patient are varied. All authorities agree that in the presence of acute obstruction, the immediate operative procedure must deal with that phase only. An attempt to extirpate the diseased segment, at this time, would be attended by an unreasonable risk. In the absence of obstruction, the surgeon may elect to handle the case in the manner that his own experience, added to that of his predecessors and contemporaries, predicates the best chance for an ideal outcome. This may be in one or more stages, since every surgeon must carry out the method in which he has the greatest confidence.

OPERABILITY OR RESECTABILITY

Attitude regarding operability has changed with the gradual improvement in surgical principles. A properly prepared patient subjected to surgery under ideal conditions will withstand procedures of such magnitude that operability has been extended to a debatable degree. There arises in our minds, at times, considerable doubt concerning the justification of effort expended. Many of us have sufficient confidence in the scientific safeguards of modern surgery to feel that any lesion not involving vital structures, which is movable after exposure, is resectable. This often leads us into complicated dissections necessitating the inclusion of neighboring structures that have become invaded by the direct extension of disease. All admit the importance of removing the vascular and lymph area supplying the region of the primary lesion; this, fortunately, is all that is needed in the majority of cases. It should be emphasized that such a dissection is even more important if the focus is small and the lymph nodes seem to be uninvolved, since it is in this group that we find our most favorable cases for cure. On the other hand, some have questioned the justification of a radical operation in the presence of liver metastases. Although, at times, I have felt discouraged about the extensive effort expended in some instances and, in

fact, have witnessed a difficult convalescence followed by a respite of such short duration that obviously poor judgment had been used, yet we have seen many incredible periods of good health and happiness follow resections of great extent, some even in the presence of liver metastases. It is this type of respite that has influenced surgeons to attempt the impossible and not for the reason I have heard quoted, "to perform a surgical stunt."

Segments of the parietes are now so often included in the block dissection for malignant disease of the colon that one no longer considers this as unusual. Lesions that have perforated to form abscesses involving the retroperitoneal area or the abdominal wall are compatible with curative surgery. Contact areas involving a ureter or kidney, the duodenum, stomach, small intestine, pancreas, spleen, edge of the liver, gall bladder, uterus and adnexa, urinary bladder, and other segments of colon can often be removed successfully. The mortality, under these conditions, will be higher than if one adopts the attitude that cure is so remote that the effort is unjustifiable. The morbidity will, of necessity, be greater and the patient may wonder whether the effort to live is worth while. The cure rate in one's statistics will be decreased proportionately by the inclusion of these extensive operations. On the other hand, a radical attitude has much to commend it. Not only does the patient have his best chance for a comfortable respite and the possibility of a cure, but the surgeon implants in the minds of his pupils the correct viewpoint toward the increasing scope of surgery.

In a previous communication,[1] we reported 107 consecutive cases of carcinoma of the colon in the regions requiring abdominal approaches, personally treated. The resectability in this group was 93.6 per cent. Since this time, we have operated upon patients in 79 additional cases, finding 10 inoperable or 87.4 per cent resectability, which shows that in patients referred to us the operable rate did not increase from 1939 to 1943. During this period a run of five lesions, originating in the right colon with such widespread metastases that only palliative ileocolostomy could be done, largely accounts for this variation. It gives, however, an overall resectability in the 186 cases of the combined groups of approximately 91 per cent.

I am sure there arises in the minds of some a doubt concerning the proper use of the term "operability." Should this term be used for resections that include all obvious disease and only when there is no evidence of liver metastases, unremovable nodes, or contact disease in neighboring structures? The word "operable" is apt to imply cure and still few of us would fail to extirpate all obvious disease, knowing full well that the chance of remote extension was likely. One does not need to believe too strongly in the possible retardation of metastatic areas by removing the primary focus. We have all seen long, comfortable respites under these circumstances. These periods of relief are

far more marked following successful extirpation of the primary disease than from palliative short-circuit anastomoses or proximal colostomy. Death from recurrent disease, especially if it occurs in the liver, is associated with fewer discomforts than it is when the primary lesion is still in situ. It seems to me that there is sufficient cause for confusion that we might do well to substitute the term *resectability* for *operability*.

MORTALITY

Any patient failing to leave the hospital alive, regardless of the time elapsed following operation, should be included in the failures of treatment. There are many ways of juggling figures to improve the facts of the situation but there seems no reasonable concept other than to include all postoperative deaths in the percentage values. In a clinic, such as ours, there will be a few moribund patients admitted, due to the accessibility of the institution to the community. If these are subjected to a palliative operation for obstruction or drainage of infection, they must be considered as surgical deaths if they fail to leave the hospital alive. Operability and mortality are closely related and if one fails to take into consideration the average type of patient seen in a large general hospital, as compared with those able to obtain private service, then figures concerning both groups are of less importance. Certainly, a larger percentage of favorable cases are seen in our private wards than in the general hospital. This definitely influences the operability and the mortality. Comparative values are possible in such a clinic on the basis of the type of operation done, since a variety of methods have been used. That deductions are useful, when applied to similar institutions only, is obvious. The results obtained in the private-patient group are likewise comparable only to similar groups elsewhere.

In the personally managed cases referred to above, 35 of the 186 patients died in the hospital, or an overall mortality rate of 18.8 per cent. This includes those whose lesions were not resectable. The operative mortality percentage can be made more attractive by eliminating the deaths in the inoperable cases and those deaths not directly related to the colon lesion or the operation undertaken to remove it. If our last group of 79 cases is analyzed in this respect, we find that of the 44 with resectable lesions of the left half of the colon only 3 patients died, a 6.8 per cent mortality. These deaths were in a 64-year-old woman who survived 38 days following resection of sigmoid, a portion of small intestine, and a total hysterectomy; a 57-year-old man who survived 30 days following resection of descending colon, part of the stomach, and the spleen; and a 69-year-old man who died from a cerebral accident 6 days following resection of the splenic flexure.

In the 25 patients with resectable lesions of the right and transverse colon suitable for right colectomy during this 4-year period, there were 10 deaths. One of these was a two-stage right and transverse colectomy

and death was due to peritonitis 9 days following the second stage. Autopsy showed an abnormality of the blood supply to the transverse colon accounting for necrosis of the turned-in segment. A 63-year-old woman died as a result of small bowel obstruction occurring between stages of a right colectomy for an extensive obstructive lesion of the hepatic flexure. This precipitated the second stage at too early a time, so that the benefits of the decompression were lost. The other 8 deaths were unrelated to technical procedures. A 76-year-old woman died of carcinomatosis 60 days after extensive resection, which included a segment of duodenum; a 51-year-old man died of subacute bacterial endocarditis 48 days after operation; a 63-year-old man, of gangrenous gall bladder with perforation 44 days after resection; a 74-year-old woman, of coronary occlusion 14 days postoperatively; a 73-year-old woman of pulmonary complications after 21 days, and a 43-year-old man died of coronary occlusion 8 days after a one-stage right and transverse colon including the splenic flexure. There were 2 deaths following the first stage in resectable lesions—one of these was in a 68-year-old man with advanced cirrhosis of the liver who succumbed in 5 days from liver failure; the other was in a 75-year-old man who had survived a two-stage resection of the sigmoid 2 years previously and had recently suffered a coronary occlusion (further coronary thrombosis occurred 5 days after ileotransverse colostomy).

Five of these deaths occurred in patients whose primary lesions were situated in the hepatic flexure. It is always dangerous to report a run of successful cases unless it is of sufficient length. In our previous report, we were foolish enough to call attention to 22 consecutive right colectomies in two stages without a death. It is of interest to us to find that in the last 67 resected lesions, there were only 2 deaths attributable to technical difficulties.

MORBIDITY

It is difficult to analyze our figures on the basis of morbidity. This, as a whole, represents a group of aged patients, many of them suffering from complicating disorders. It is desirable to attempt to improve their general condition before subjecting them to any operative procedure. This may not be possible, since acute obstruction or infection often makes an early attempt imperative. Although associated diseases account for many of the fatalities, it is to be remembered that many of the survivors also had serious concurrent maladies. This would be expected in any lesion affecting an older age group.

The time spent in the hospital hardly represents a fair estimate of morbidity, yet it seems to be the only tangible evidence available. It might be possible to search out the duration of invalidism prior to hospitalization and make some attempt to determine the further convalescence prior to returning to usual occupations. This would vary tre-

mendously, depending upon so many factors of age, sex, type of work, and the necessity for it, that it hardly seems feasible. Many of the individuals seeking relief have worked up to the day of admission, while others have long been retired. That a large percentage of the survivors do return to their usual occupations is evident.

One may attempt to analyze morbidity on the basis of cost of hospital care. This would entail the details necessary for modern surgical care and would include blood transfusions, expensive drugs, oxygen, and special nursing service. Although the private ward patients often are permitted luxuries in this respect, none of the General Hospital patients are restricted in these matters if such additional aid may make the difference between recovery and death. That useless expenditures in hopeless cases are often indulged in cannot be denied. There is, however, an educational element for the resident personnel that justifies these procedures to some extent.

Based on our own 93 cases in the past 5-year period, we find that preoperative preparation averaged 4 days. This is a short period due to the fact that even in those who did not have marked obstruction, a preliminary decompression of the bowel was the rule. The time interval between stages averaged 11 days. The total average time for hospitalization of the survivors was 39 days. In the General Hospital group for the same period, the preoperative days averaged 5½. The total days for the survivors averaged 44. All these figures include time necessary for the final closure of preliminary colostomies. Most of the cecostomies were of the type that spontaneously closed.[2]

That a shorter term of hospitalization was obtained in the patients subjected to one-stage procedures is admitted.[3] The increased mortality in the one-stage group, however, far outweighed the added morbidity in the two-stage group. At present, there is a definite tendency with the aid of preliminary succinylsulfathiazole and the Miller-Abbott tube to increase the number of one-stage operations. This may materially decrease morbidity. It only remains to be seen whether or not these measures will offset the safeguard our patients have had from two-stage operations. It may well become evident that we should include these precautions in addition to multiple stage procedures, thus further reducing mortality. The average added morbidity in the multiple stage procedures is, in fact, a matter of less than two weeks.

SURGICAL PROCEDURES

Consideration of surgical procedures for cancer of the colon involves the following general principle: First, the patient's life must be safeguarded and second, the patient's health must be restored. One can circumvent the first principle by doing only the most palliative operation to relieve the symptoms temporarily, or it is possible to adopt the attitude that radical operation carries such a great hazard that it is un-

justifiable. Both of these concepts are wrong and should be discouraged. It is delightfully enlightening to find that in this community a large number of excellent surgeons meet this problem so seldom that they feel incompetent to do a good operation for cancer of the colon and refer the patient to a clinic, where so many such cases are treated that an adequate understanding of the situation gives the patient a fair chance. These honest men inspire the confidence of their patients and the respect of their colleagues, while the surgeon who fails to recognize his limitations has neither. After all, there are estimated to be approximately 15,000 cases of cancer of the colon in the United States in one year.[4] If these are parceled out equally to all surgeons, no one man would have sufficient experience to deal with the case properly. The present attitude concerning the matter concentrates these patients in the larger teaching clinics. This serves the purpose of developing the best methods for successful treatment.

There are a variety of well-thought-out operative procedures for patients with colon cancer. Stress has beeen placed upon the importance of early extirpation of the growth. This is indeed desirable from the standpoint of the mental state of the patient and the convenience of the surgeon. Those who champion one-stage procedures are apt to lay great emphasis on the benefits derived from prompt removal of the diseased area. It must be recognized, however, that too much urgency in this direction may result in an unsuccessful outcome. Most of these growths produce a certain amount of obstruction. All of them are grossly infected. A combination of obstruction and infection presents a problem that has long been recognized as a serious hazard to abdominal surgery. Many nonresectable lesions can be made operable by preliminary bowel drainage. Consideration must be given to exteriorization methods, as well as to one- or two-stage procedures with anastomosis. So-called aseptic anastomosis versus open sutures must be discussed. Adjuncts to successful operations, such as proper preoperative preparation, chemotherapy, and the Miller-Abbott tube, will be taken up later. Since there is considerable difference in the mortality rate in the extirpation of malignant growths in various segments of the colon, it is desirable to discuss these regions separately.

The *right colon* is involved in about 25 per cent of the patients coming to our clinic. The disease in this area may fortunately manifest itself reasonably early by bleeding, by intermittent discomfort in the right lower quadrant, or by intussusception. Anemia and fatigability may lead to investigation that discloses a right colon lesion. Many of these cases, however, produce none of these symptoms forcibly and due to the natural elasticity and large caliber of this segment, obstruction is a late manifestation. In spite of this, it appears that survivors have a better chance for cure than those whose lesion affects other regions of the bowel. This is probably due to the anatomic arrangement which makes it easier

to include the entire vascular and lymph node area in the resection. All agree that the logical procedure must include the terminal ileum and the right half of the transverse colon. The operative mortality, however, remains greater on this segment than elsewhere.

A group of 83 cases has been reported by Mayo,[5] with a mortality of 8.4 per cent. He prefers a one-stage procedure with open anastomosis. In the presence of obstruction, occurring in a small percentage of his cases, a two-stage modification was used. Doubtless, his preoperative preparation is excellent and one must bow to his surgical technique and to his judgment in the selection of cases for the proper procedure. In the hands of less experienced and less skillful surgeons, this method of attack would be associated with a mortality rate of approximately 20 per cent.

Lahey and Sanderson[6] have championed a Mikulicz type of resection as a primary operation. The closure of the originally complete ileal fistula is enhanced by an approximation suture between the colon and small bowel. The operation for final closure of the fistula requires a short period of hospitalization. In 112 resections for cancer by this method, they report 19 deaths, a mortality rate of 17 per cent. This procedure has been so well liked by this group that they have preferred it to all others. It does allow an immediate dissection in a virgin field and has that same advantage of a one-stage resection with anastomosis. It eliminates the danger of anastomosis added to the resection. Although others have found the complete ileal fistula such a serious problem that they have abandoned this type of operation, there are doubtless many tricks learned by experience to lessen this hazard.

Stone and McLanahan[7] prefer a one-stage resection in the absence of complete obstruction and stress immediate aseptic anastomosis. In 16 patients treated in this manner, there were 3 deaths.

Garlock and co-workers,[8] in their excellent analysis of their colon cases, report 7 completed two-stage right colectomies without a death, while other procedures including nonresectable lesions brought their total mortality in 30 cases to 33 per cent.

McKittrick[9] reports 11 one-stage right colectomies with 3 deaths and 17 two-stage procedures with 1 death.

I[3] analyzed the results at the Massachusetts General Hospital between 1925 and 1936 and found that one-stage resections produced a mortality rate of 20.5 per cent in 73 cases, while 18 two-stage operations done by the same group of surgeons in poorer risk patients resulted in 2 deaths or a 11 per cent mortality. This caused me to advocate the two-stage attack and I still believe it is the safest and most logical procedure.

There are certain lessons that we have learned that are worth recording. In the first place, it is well to delay the preliminary ileotransverse colostomy until the patient is in the best preoperative condition that can be obtained. Preliminary use of succinylsulfathiazole and the

TABLE I

CARCINOMA OF COLON*

	1 STAGE	DEATHS	MORTALITY (%)	2 STAGE	DEATHS	MORTALITY (%)	TOTAL	DEATHS	MORTALITY (%)
Right colectomies	13	7	53.8	44	7†	15.9	57	14	24.5
Left colectomies‡	16	3	18.7	70	8	11.4	86	11	12.7
Total resectability of stage operations	29	10	34.4	114	15	13.1			
Other resections§							26		
Not resectable							17	10	23.3
							>43		
Grand total (Resectability, 91 per cent)							186	35	18.8

*Exclusive of carcinoma of the rectum. Personal cases, 1925-1942.

†Includes 2 deaths after first stage when 2-stage procedure was planned.

‡Complementary cecostomy was done in these 1-stage operations.

§Includes transverse colectomies not done with right or left colectomies, obstructive resections, turn-out operations, and combined abdominoperineal resections.

Miller-Abbott tube are recommended. Aseptic anastomosis of the modified Parker-Kerr type has, in our hands, been satisfactory. The objections to two operations are not too convincing. They are often a safeguard for the patient and, after explanation, are always accepted by them with little complaint. The so-called double opportunity for surgical complication has not proved to be such a menace as is so often quoted. There can be no doubt that the first operation increases the technical difficulties of the second. We have also had one fatal case, mentioned above, of obstruction of small bowel from herniation through the trap left by the preliminary ileotransverse colostomy. Other nonfatal obstructions have occurred and have, at times, hastened the second stage. The Miller-Abbott tube has been helpful in preventing and dealing with this complication. One may make this trap larger, and therefore less likely to permit obstruction, by placing the anastomosis more than 12 inches from the ileocecal valve. After trying division of the terminal ileum at the time of anastomosis, we have abandoned it because the cut, fat edge of the mesentery produces a hazard by affording an opportunity for the small bowel to become fixed to it between stages. Anastomosis in continuity should be done with the ileum lying without torsion or tension against the center of the transverse colon. This allows for a better closure of the trap and a smooth peritonealization of the inner side of the cut mesentery at the second stage, thus reducing to a minimum the opportunity for ultimate small bowel obstruction. After the second stage, it is rarely possible to peritonealize adequately the right gutter. Therefore, we routinely drain this area through a stab wound in the flank. This has proved satisfactory and rarely have we been faced with a residual abscess in this region. Various methods have been suggested to manage the large, often infected, dead space resulting

from resection of an extensive growth in this region. Sulfonamides and drains of one kind or another have been used. Recently, Jones and his associates[10] advocated the Mikulicz pack for this purpose.

The *transverse colon* has been involved in approximately 11 per cent of the cases we have studied. If the lesion is in the proximal third of this segment, we believe it can be best treated by the method used for the right colon. On the other hand, if the mid-portion of the gut is involved, we are convinced that preliminary ileocolostomy is disadvantageous. First of all, in this region one may not get an accurate idea of the extent of the lesion by roentgenograms. After exploration, it is well to have in mind various operative procedures. Due to the often heavy greater omentum, this segment lends itself poorly to obstructive resection. Resection with aseptic suture in one stage has much to commend it. Stone and McLanahan[7] had only one death in 16 consecutive cases of transverse colectomy treated in this manner.

If obstruction is present, one may use preliminary cecostomy to advantage in lesions beyond the midcolon. The danger of applying it may be that the lesion cannot be accurately localized so that the cecostomy handicaps the final procedure. Preliminary ileosigmoidostomy may be considered. This may lead to an unnecessarily wide resection or may ultimately leave behind sizable defunctioned segments of bowel. Under no circumstances will I concede that preliminary tube ileostomy is justifiable for obstruction. If ileostomy under these circumstances must be indulged in, it must be complete and placed low in the abdominal wall. In these regions, it is apparent that intelligent preliminary use of the Miller-Abbott tube will find great usefulness.

In addition to the objections already stated to the stereotyped two-staged operations for lesions of the middle or distal thirds of the transverse colon is the very humiliating experience, quoted previously, regarding the abnormality of the blood supply to this region. Apparently, the usual anastomotic artery arising from the inferior mesenteric is not always present. If the resection is done in a virgin field, it would be easier to determine the viability of the bowel ends even in the presence of an abnormal fat deposit.

In the *distal transverse, splenic flexure, and upper descending colon,* we have an ideal situation for preliminary cecostomy followed by resection and aseptic anastomosis. The resection is often best accomplished through some modification of the transverse incision. In obese patients, this is particularly helpful. One may, with justification, prefer obstructive resection in this region. Immediate resection with anastomosis without preliminary drainage appears to be more hazardous in this segment than in others. It has been our experience that obstruction is more common in the splenic flexure than elsewhere in the bowel. Contiguous structures, such as the tail of the pancreas and the spleen as well as segments of small bowel and the fundus of the

stomach, are often involved. This means that preliminary decompression is even more imperative in this region. The site is rare but appears to represent a good one for cure, since metastases occur late.

The *descending colon*, being a straight tube, is invaded by cancer with less frequency than any other segment of its length. In our cases, only 9.6 per cent were in this region and this figure includes the splenic flexure.[1] Representing one of the fixed areas of the colon, one cannot exteriorize the segment involved with the same ease that is met in the sigmoid. Mobilization, however, is not difficult and can be enhanced by dividing the suspensory ligaments to the splenic flexure. Obstructive resection can be accomplished if proper effort is made to free the lateral attachments. This method has been popular and, if properly done, gives a satisfactory result. Preliminary cecostomy, followed in approximately 10 days by resection and aseptic end-to-end anastomosis, has been the method of choice in our hands. When one includes the efforts expended in closing the colostomy following obstructive resection, there is little choice on the basis of morbidity. Although an occasional preliminary tube cecostomy may heal slowly, it rarely requires surgical closure. In the absence of obstruction, one may elect to do resection and suture with or without complementary cecostomy. If no cecostomy is used, one should take advantage of the preliminary and postoperative decompression afforded by the Miller-Abbott tube. Complementary cecostomies heal more promptly than preliminary cecostomies. This is due to the use of a smaller tube and the shorter period of need for it.

The *sigmoid* represents the most frequent site of cancer in the large bowel, 53.9 per cent in our series. Tortuosity, favoring stasis, may be the chief reason for this. Bleeding and early signs of obstruction occur with great frequency. Although the operability in this region is high and the operative mortality is low, the cure rate of survivors is considerably less than it is in the right colon. Lymphatic spread and earlier liver metastasis probably account for this discrepancy.

Many patients with these lesions present themselves with complete obstruction. In order to relieve the acute phase of this complication, many methods have been suggested. The simplest and safest of these is cecostomy, which, if done promptly and with proper technique, is spectacular in its immediate effect. If the growth is large or has produced an abscess by perforation, it is often necessary to follow cecostomy a few days later by complete transverse colostomy. The method of Devine[11] has met with considerable popularity in this country. Having tried this a number of times in our clinic, we find it has sufficient disadvantages to offset those of simple loop colostomy and it has been practically abandoned by most of our staff. It is necessary, however, to rest the infected bowel until the inflammatory reaction subsides sufficiently to allow a thorough cleansing by repeated irrigations before an attempt is made to resect the primary disease.

That safety and operability are increased by this procedure, there can be little doubt. The only price paid for these advantages is the increased morbidity of additional hospital days.

Although the majority of growths in the sigmoid produce some obstruction by the time the surgeon sees them, many can be made operable without preliminary decompression. Often the bowel can be prepared by catharsis and enemas. The laxative effect of succinylsulfathiazole is spectacular. While the patient is receiving adequate preparation for surgery by increased vitamin intake, restoration of fluid and chemical balance, the bowel can be made a safer structure for surgery. Although it is the feeling of some that nothing more than such preparations are necessary before resection and immediate suture, a large number of surgeons prefer some form of preliminary decompression if suture is contemplated. Whipple[12] and Cave[13] have had a satisfactory experience with the use of the Miller-Abbott tube for decompression in some colon lesions, particularly the right. At this writing, I personally prefer a routine preliminary tube cecostomy followed 10 days later by resection and aseptic anastomosis. If one prefers the obstructive resection of Rankin in the left colon, there will be no need for preliminary decompression save in those patients who have complete obstruction on entry. The use of a small catheter vent in the proximal segment, placed near the clamp, has been found helpful in many cases where obstructive resection is used.

If, on exploration, one finds a lesion that would be best treated by proximal decompression, there is little excuse for the often used sigmoidostomy a few inches above the growth. This procedure complicates the ultimate resection tremendously. If, under these circumstances, the surgeon would make a small transverse incision high in the abdomen and bring out a loop of transverse colon, closing the original incision without drainage, he would greatly enhance the ultimate curative procedure.

Often one meets the situation of a low growth in the sigmoid that requires a change of plan. If the extension has involved the pelvic floor, one usually finds that combined abdominoperineal resection is the safest and easiest procedure to use. There are, however, two definite alternatives in selected cases. In the elderly poor-risk patient, one may do well to consider the "turn-out" operation as practiced by D. F. Jones.[14] This consists of sectioning of the bowel below the growth and turning it in as a blind rectal stump. The tumor and mesentery are removed leaving an end colostomy. Care must be taken to leave the closed segment above the peritoneal floor. If this is not possible, one must establish drainage in the ischial fossa from the perineum. One should be especially careful here to add the procedure, advocated in all bowel resections, of adequate dilatation of the rectal sphincter or a division of the sphincter muscle. It is possible after the

turn-out operation to re-establish continuity of the bowel at a later date but usually this is not practical.

The other possibility, and one more frequently used, is a low anastomosis at the time of resection. This is greatly enhanced by a preliminary complete transverse colostomy, since this is the best method to allow proper preoperative cleansing of the bowel. In this region, aseptic anastomosis is more difficult and a well-prepared segment adds to the safety of open suture. Rankin has advocated the stepping down of the pelvic floor to allow this low suture to come within the peritoneal cavity and when possible this should be done. Stricture, requiring tedious dilation, results if the anastomosis is placed below the pelvic floor.

GENERAL CONSIDERATIONS

Chemotherapy is at the moment in great favor and much is still being learned about this tremendous aid in colon surgery. Intraperitoneal use of sulfanilamide has been received enthusiastically. Experience has shown that this drug may be detrimental to the liver when so used, since it is so rapidly absorbed through the portal system. This has led to a reduction in the amount of the drug used in this manner and to the consideration of preliminary use of sulfadiazine to an adequate blood level. Also, through the research of Poth,[15] there has been developed succinylsulfathiazole. This drug has many advantages in the preparation of patients with colon lesions for operation. It is supposed to be poorly absorbed into the general circulation and to have the effect of reducing the bacterial count of the colon contents. It further produces a laxative effect, which is advantageous in these cases. The daily dosage is worked out on the basis of kilograms of body weight which must be modified in obese patients. The preliminary use of 8 Gm. per day for five days in the average adult is perhaps a good general rule. We have been enthusiastic regarding the unusually smooth convalescence in combined abdominoperineal resection following its use.

Firor[16] has called attention to the tendency of bleeding from the tumor following its use. We have observed this complication in at least 3 patients in a small experience; in none of these was the hemorrhage of a dangerous degree and all took place on the fifth day, or the day prior to the planned operation. In one instance, petechial hemorrhages of the brain, as well as generalized gastrointestinal bleeding, occurred postoperatively which, we believe, contributed to the patient's death. The prothrombin time in this patient was not appreciatively elevated. It is fair to say that intravenous pentothal sodium, used as an adjuvant anesthesia in this case, may have played a role in the hemorrhagic tendency. At post-mortem, a moderate amount of local infection was found near the operative site, which had fol-

lowed an open anastomosis in the sigmoid. This is the only instance in which we have been able to observe the local area following its use, but we have been impressed by the lack of clinical evidence of intraperitoneal infection in all other cases.

Although we believe that proper use of the sulfonamides will prove helpful in dealing with colon surgery, we cannot overemphasize the caution that it is to be looked upon only as an aid and is not to permit the slightest breakdown in the proved surgical principles heretofore established. One may keep the blood level at a satisfactory point by the postoperative use of sulfadiazine. Delayed infection may be expected under these circumstances. Late abscess formation and wound sepsis, requiring drainage, have occurred occasionally in our cases following its use. There has been, however, no increase in these complications and aside from the occasional prolonged convalescence, it is a small price to pay for the obvious benefits derived. Pulmonary and urinary complications are greatly reduced.

The *Miller-Abbott tube* has been helpful in dealing with cancer of colon. We have previously referred to Whipple's enthusiastic report concerning its use. McKittrick and Warren[17] have stressed another use, which is worthy of emphasis. When a colectomy is planned, one often finds an abnormal interference from normally full small bowel. If the Miller-Abbott tube is introduced 36 hours before operation and suction has been maintained, one finds the small intestine decompressed and fluted on the tube in such a fashion to make it a simple procedure to get at the colon with very little need of trauma to the peritoneal surface of the bowel. This not only makes the operation easier to accomplish but leaves a decompression of the whole intestinal tract above the suture line. This prevents the occasional ileus seen following operations of this sort and is, in fact, at times a lifesaving procedure if used as an afterthought rather than as a precaution.

Experience with the Miller-Abbott tube causes me to mention these warnings. The use of the stylet, as advocated by Abbott[18] for introduction of the tube, is a tremendous advantage. If the technique is followed closely, no harm results and many needless roentgenograms are unnecessary. The time involved under the fluoroscope is short and one knows how much reliance can be placed on the tube. This technique is tremendously important in the presence of obstruction or ileus. One may wait for nature to propel the tube through the pylorus when using the tube for precautionary measures, but never if the need for it is immediate or urgent.

Having had the harrowing experience of not being able to deflate an apparently perfect balloon after operation and the need of an emergency laparotomy in the nick of time to prevent a fatal gangrene of the intestine in a patient on whom a preoperative tube was passed, I

wish to urge that all surgeons request the anesthetist to deflate the balloon while the abdomen is open. This, in addition to a careful construction of the balloon beforehand, may prevent others from encountering such a complication.

Delayed wound closure has been re-emphasized by Coller and Valk.[19] Although wound sepsis following operations upon the colon is not often fatal, it does occur in a certain percentage of cases. No matter how much care is used in protecting the wound surfaces or how accurately instruments and gloves used in the handling of the bowel are discarded, there can be no doubt that primarily closed wounds under these circumstances become infected in a greater number of cases than in the usual clean abdominal operations. We have used Coller's technique or a modification of it with great satisfaction. The sutures are often tied without anesthesia but in the timorous patient, a small dose of pentothal sodium permits the procedure without the patient's knowledge. Pemberton and Black[20] have modified Coller's technique somewhat and report the advantages of the delayed closure in their clinic. We feel that this adjunct to colon surgery should be particularly emphasized now, since so much reliance is being placed on the sulfonamides. Not only is the local use of sulfonamides in wounds of this kind detrimental to healing but delayed wound infection, occurring following the use of these drugs, frequently prolongs convalescence well beyond the usual period of time.

SUMMARY AND CONCLUSIONS

1. Carcinoma of the colon accounts for at least 11 per cent of the deaths from cancer in the United States. It is a favorable site for cure, when diagnosed and treated early. Further effort should be made to reduce the time interval between onset of symptoms and hospital admission.

2. Resectability should be substituted for the term operability. In our own 186 cases of colon cancer, 91 per cent were resectable.

3. Mortality and morbidity are directly related to resectability. Morbidity figures should include time used for closure of fistula.

4. Immediate removal of the growth is not as important as proper preoperative preparation. This includes the use of sulfonamides, cleansing the involved bowel, the preliminary use of the Miller-Abbott tube, and supportive measures.

5. Preliminary ileotransverse colostomy with aseptic suture is advocated for lesions of the right colon and the proximal third of the transverse colon. Preliminary tube cecostomy is advocated for lesions of the remaining colon. These procedures will increase the resectability rate in this group of patients, which to our minds offsets the added morbidity. It also appears to reduce our mortality rate.

6. Resection with immediate aseptic anastomosis is our method of choice for the second stage. The Parker-Kerr type of anastomosis has been satisfactory to us.

7. Delayed closure of the abdominal wound by Coller's technique 48 hours after resection is recommended.

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CANCER OF THE COLON

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IN SPITE of improvements in both immediate and end results obtained by resection of the colon, reported during the past decade, the condition still constitutes an important public health problem, and surgeons are still not entirely agreed as to the best method of treatment. The chief problem, as with cancer elsewhere in the body, is how to get the patient to come to the doctor early in the course of the disease, and then how to get the first doctor who sees the patient to make the diagnosis promptly and arrange for resection to be done. That the condition can often be cured by resection, and by no other method at present available, has been amply demonstrated, and the differences of opinion among surgeons have to do largely with differences in the technique of resection and re-establishment of continuity of the bowel after resection. There is quite general agreement as to the amount of bowel and mesentery that needs to be removed, for this is based on anatomic studies of the regional lymphatic drainage and the blood supply to the parts which have been studied rather carefully. In most clinics a plan of management has been established which works well in the hands of the surgeons in that clinic, though it may differ considerably from methods used elsewhere. At this clinic our preference is for anastomosis, by either an open or a closed method, at the same time the resection is done, rather than for the use of delayed anastomosis by some modification of the Mikulicz principle. In our hands, over a period of years, delayed anastomosis has led to prolonged or repeated hospitalization, with no evidence of better results than by immediate anastomosis. At a municipal institution such as the Cincinnati General Hospital one sees probably the worst and most frequent instances of delay on the part of both patients and referring doctors as far as early diagnosis is concerned. Most of the patients seen by the surgical service here have had the disease for many months, often for years; most of them have complete obstruction when admitted to the hospital, and many have reached the stage when resection is no longer possible. Almost all of them come from lower income groups and many have been living on poor diets and under poor hygienic conditions. They present a sharp contrast to patients seen in private practice, such as those that present themselves at a private clinic. For the five-year period from the end of 1937 to January, 1943, we have reviewed the cases of resection of the large bowel for

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cancer from the Cincinnati General Hospital and the Christian R. Holmes Hospital, performed by various members of the resident and visiting staffs. A total of seventy patients with cancer of the large bowel were seen, of which forty-five were treated by resection.

At the General Hospital twenty-five cases out of forty-eight were treated by resection. At the Holmes Hospital, working with private patients, twenty out of twenty-two were treated by resection. This illustrates vividly the difference in operability seen in a private and a charity clinic. The operability rate in the total group is shown in Table I.

TABLE I

OPERABILITY RATE

	CASES	RESECTIONS	OPERABILITY (%)
Right colon	28	17	60.7
Transverse colon	8	7	87.5
Left colon	34	21	61.7
Total	70	45	64.2

This rate of 64.2 per cent corresponds fairly well with rates reported from other clinics. It must be pointed out, however, that if General Hospital cases alone had been considered, the rate would have been only 52 per cent, while at the Holmes Hospital it was 90.9 per cent. It must be remembered in this connection that when dealing with private patients, one that is unquestionably inoperable may never be admitted to the hospital, but remains at home. In a charity institution, this situation is often entirely reversed, a family or a family doctor sending the patient to the hospital to die. At times there may be considerable difference of opinion as to what constitutes an operable case. Several of the patients at the General Hospital probably should not have had resections. At least three had liver metastases at the time of operation. One had a fistula from a perforated carcinoma of the sigmoid. One had a sigmoid colostomy performed elsewhere immediately above a carcinoma which was said to be inoperable. In this instance resection of the colostomy and tumor was carried out in one stage. In three, a palliative ileotransverse colostomy was done, although resection was never accomplished.

The following general plan of management is used here for patients coming to the hospital with signs of intestinal obstruction. A preliminary examination is first made to determine, if possible, whether the obstruction is in the small or large bowel. Such things as distension, intestinal patterns, peristaltic activity are, of course, looked for. In addition, especial attention is paid as to whether there is a palpable abdominal or pelvic mass, a scar of a previous operation, a strangulated hernia, or other localizing sign. If there is no strangulated hernia the patient next goes to the x-ray room for flat films of the abdomen. This is followed by a barium enema when flat films alone are not conclusive. If the obstruction can be localized in the large bowel, other than the

cecum, ascending colon, or hepatic flexure, a cecostomy is done under local anesthesia as soon as general preoperative measures have been carried out. In patients without definite obstruction, and in whom large bowel cancer is suspected, the diagnosis can generally be established by barium enema, and double contrast enema, or by sigmoidoscopy in low-lying lesions. It is often surprising to us to see how many patients have a palpable abdominal mass known to them or to their physician, without any adequate study having been carried out. The diagnosis having been established with reasonable certainty, a period of preoperative preparation is started. The general features of this preparation are the same, but may be varied depending upon special indications. The patient is placed on a high caloric, low residue diet, and an attempt is made to empty the large bowel as completely as possible. If a cecostomy has been produced, irrigations through the cecostomy tube are given daily as well as rectal enemas. If no enterostomy has been performed, the patient is given mild saline cathartics daily to give a watery stool which will pass through the partial obstruction if one is present, and this is supplemented with daily enemas. It is important to get rid of all the barium from the barium enema, for if this remains above the obstruction it may become inspissated and form hard, almost rocklike masses. If in doubt, fluoroscopic examination or x-ray films should be used to determine this point. Adequate vitamin intake either orally or parenterally is advisable. The blood count and plasma proteins should be brought to satisfactory levels if they are low, by blood or plasma transfusions. The giving of sulfonamide compounds by mouth preoperatively has been used sporadically, but has not been adopted as a routine. Further clinical trial is desirable before the value of such treatment can be assessed. Twenty-four hours before operation, the patient goes on a liquid diet and lead and opium pills I, t.i.d., are given to place the large bowel at rest.

The general management differs somewhat depending on whether the cancer is situated in the right or left half of the colon, and on whether obstruction is of high grade or is relatively unimportant. Signs of associated local inflammation may also influence what is done. Cancer of the cecum and ascending colon is rarely associated with high-grade obstruction. This is probably due to the fact that the lumen of this portion of the bowel is large and the contents fluid or very soft. The anemia which is described as characteristic of cancer in this location we have not found to be regularly present. Tumors here are often polypoid and bulky, and in many of the ones we have seen a mass was palpable at the time of admission to the hospital. In many of them, infection had occurred, and an inflammatory mass with or without abscess formation was present in addition to the tumor. The differential diagnosis between appendical abscess, diverticulitis, tuberculosis, and infected tumor may be exceedingly difficult in such instances. In managing infected tumors we usually perform first an ileotransverse colos-

tomy through a right rectus incision, dividing the ileum and turning in the distal end. The diversion of the fecal current usually allows the inflammatory reaction to subside, and at a subsequent stage, the resection is carried out through a transverse incision. Ileotransverse colostomy as the first procedure was carried out five times, but in three of the cases it was only palliative and was not followed by resection (see Table II). In the other two cases, resection was carried out several weeks after the anastomosis. Only three of the seventeen patients with cancer of the right side of the colon which were resected showed obstruction. Of the twenty-eight resected for cancer of the transverse and left colon (see Table III), thirteen or almost one-half had complete or almost complete obstruction at the time of admission to the hospital. In all of these a cecostomy or transverse colostomy was done to relieve the obstruction, and the resection done subsequently. In eight others a preliminary decompression was done prior to the resection, leaving only seven of the twenty-eight that had resection without preliminary decompression. This does not mean that we favor preliminary decompression but we may be forced to use it due to the particular situation presented by the patient. In the absence of obstruction we do not hesitate to perform resection with immediate anastomosis without decompression.

TABLE II

RIGHT COLECTOMY WITH ILEOTRANSVERSE COLOSTOMY

Cecum	7	End-to-side (one stage)	2
Ascending colon	3	Side-to-side (one stage)	13
Hepatic flexure	7	Side-to-side (two stage)	2
Total	17		17

TABLE III

RESECTIONS TRANSVERSE AND LEFT COLON

Transverse	7	End-to-end	23
Splenic flexure	3	Side-to-side	3
Sigmoid	18	Mikulicz	2
Total	28		28

Anesthesia in practically all cases is obtained by nitrous oxide oxygen and ether induction, followed by ether through an intratracheal tube, using a closed system. With an anesthetist, properly trained in this method, it gives adequate relaxation, and a low incidence of postoperative pulmonary complications. At the completion of the operation, the trachea is sucked dry with a catheter through the intratracheal tube before it is removed. Preoperative medication consists usually of morphine and scopolamine in a ratio of 25 to 1 about three-fourths hour before induction. Nembutal, gr. 1½, is generally given about one and one-half hours before operation. Postoperatively, the patient is turned frequently. He is instructed to take ten deep breaths at least three times a day, preferably every two hours, during the first few days.

He is watched carefully for signs of atelectasis, and at the first evidence of this complication, he is turned with the affected side up and encouraged to cough. In most instances this leads to expulsion of the occluding plug, and aspiration with a catheter is not necessary, although aspiration with or without bronchoscopy is used if posture and coughing fails to accomplish the desired result.

In uncomplicated cancer of the cecum, ascending colon, or hepatic flexure, a one-stage resection and anastomosis is done. During recent years the procedure has been carried out through a transverse incision extending into the flank, similar to that described by Hoag[2]. The patient is turned slightly to the left side and usually the gall bladder bridge is elevated slightly to obtain better exposure. We believe that the exposure through this incision is better than that obtained by a vertical incision, peritonealization of the defect is easier, and the patient has less postoperative discomfort. After careful exploration of the abdomen to determine whether metastases to the regional glands or to the liver are present, the cecum and ascending colon are mobilized by dividing the lateral peritoneal reflection and rolling the bowel medially. The ureter and spermatic or ovarian vessels must be identified and the former traced down over the brim of the pelvis and up to the kidney. The rest of the fat and gland-bearing tissue in the flank must be freed and carried medially with the bowel and mesentery. The dissection is carried up to the origin of the right colic artery. At the upper end, the retroperitoneal portion of the duodenum is identified and carefully freed from the mesentery of the colon. In lesions of the hepatic flexure and first part of the transverse colon it may be necessary carefully to free the transverse mesocolon from the pyloric end of the stomach or first portion of the duodenum. After freeing the bowel well beyond the lesion, and deciding upon the site for its division, the mesentery is cut across from that point to the origin of the right colic artery. We prefer to divide the peritoneum first, and isolate and ligate each vessel separately with silk, rather than divide the mesentery between clamps and then tie off each clamp as is so often done. The mesentery of the terminal 5 to 6 inches of ileum is similarly treated by dividing the peritoneum on each side and isolating and transfixing each vessel with silk. In most instances we have closed both the terminal ileum and the transverse colon, and then done a side-to-side anastomosis, although in a few recent cases the colon only has been closed and the end of the ileum implanted into the side of the colon by a closed method. If side-to-side anastomosis is to be done, the bowel is divided at both ends of the portion to be resected with the cautery between straight Kocher clamps, and removed. The method of closure of the stump is important. A number of plans have been employed but two are used most often. One of these is simple closure with a series of Halsted mattress sutures of medium silk. The other is the use of an inverting right angle suture (Cushing suture) of catgut over the Kocher clamp, which is continued

back for a second row. This may be reinforced by several mattress sutures of silk. Each of these methods of inversion turns the bowel in completely so that there is no closed cavity such as is obtained when the bowel is tied before inversion.

After both ends of bowel are closed, the terminal ileum is held alongside the longitudinal band of the transverse colon, and a side-to-side anastomosis is done near the ends in order to leave as little blind stump as possible. The method used is that of the Halsted gastroenterostomy. The field is carefully walled off with gauze packs. Traction sutures of silk are placed at each end of the proposed anastomosis, and a posterior continuous suture of medium silk is placed (Fig. 1, *1*). Halsted mattress sutures of silk are then laid anteriorly (Fig. 1, *2*). These are next pulled aside, half to each end. Before opening the bowel, a temporary occlusion is produced to prevent gross soiling. Formerly rubber-shod clamps were used for this purpose. Recently, however, we have used a device made by our diener in the experimental laboratory. This consists of a bar of lead about 5 by 3 mm. in cross section. This is covered with soft rubber tubing. When bent on itself like a hairpin, it can be placed across the bowel and will hold approximately any position into which it is placed. It can be placed around the bowel with just the amount of pressure desired and will occlude sufficiently to prevent fluid and gas from escaping. Two such devices can be used, one across the terminal ileum, the other across the transverse colon. At the site of anastomosis itself no clamps are used. The bowel is held up by the assistant lifting the traction sutures, and there is ordinarily no escape of intestinal contents. The bowel is opened with a knife and scissors, and bleeding points are clamped and tied with 000 chromic catgut (Fig. 1, *3*). The posterior suture line is reinforced with a continuous lock stitch of 0 or 00 chromic catgut which goes through the entire thickness of both bowel walls (Fig. 1, *4*). The ends of the anterior row of mattress sutures are then pulled up, the traction sutures are cut or pulled aside, and when the mattress sutures are drawn up to approximate the bowel and tied, the anterior lip of the anastomosis is closed (Fig. 1, *5*). A Lembert suture of fine silk is then placed between each two mattress sutures. The angles of the anastomosis are reinforced with mattress sutures of silk, and the occluding rubber-shod clamps or lead bar clips are removed. After removing the protecting gauze packs, the gloves are changed before continuing the operation. The overlapping folds of mesentery are sutured together to close the defect, and the terminal ileum and its mesentery are dropped into the flank to cover and partly peritonealize the raw area. In recent months, sulfanilamide powder has been dusted into the peritoneal cavity before closure. The exact method of closure has differed with individual operators. As a rule, the peritoneum is closed with continuous catgut. The wound is then thoroughly but gently irrigated with saline solution, the muscle and fascia closed with interrupted figure-of-eight sutures of doubled medium

black silk or of No. 1 chromic catgut, and the skin with interrupted fine silk. With catgut suture of the fascia, stay sutures may be used, but with silk closure ordinarily no stay sutures are placed. In a few cases closure with through-and-through silver wire was employed.

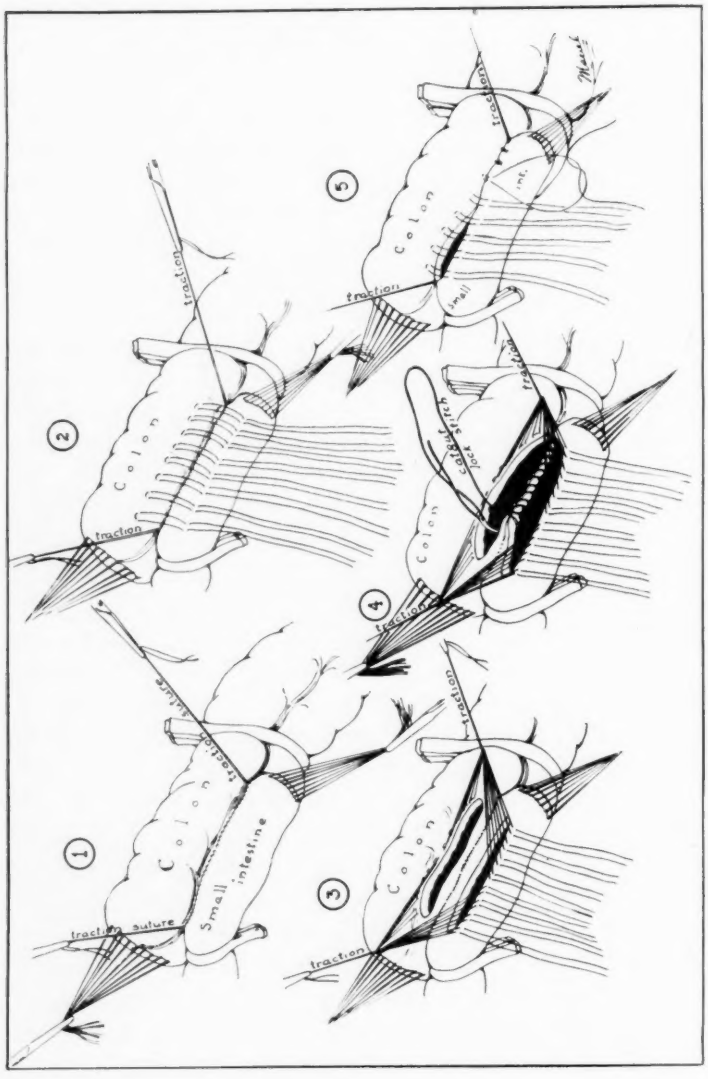

Fig. 1.—Steps in side-to-side ileocolostomy. (*1*) Posterior continuous suture of silk between two traction sutures. (*2*) Anterior row of Halsted mattress sutures placed. (*3*) Mattress sutures pulled aside; incisions made in bowel and vessels clamped and tied with catgut. (*4*) Posterior lock stitch of catgut through all layers of bowel. (*5*) Mattress sutures pulled up and tied.

In two recent cases in which end-to-side anastomosis was performed, the procedure used was a modification of a method described by Rankin.[1] After the cut end of the colon is closed, a site is selected for the anastomosis along the longitudinal band of the colon. A portion is tented up by grasping it with two Allis clamps. A straight Kocher clamp is then placed across this area longitudinally and the protruding portion, which is made to correspond in size with the diameter of the ileum, is excised

with the cautery (Fig. 2, *2*). The stump of the ileum, which is held in a Kocher clamp, is then approximated to the defect in the colon and the anastomosis is begun. Using an atraumatic needle a posterior running suture of chromic catgut is placed with a tie at the beginning and a lock at the other end, leaving both ends long in order to tie them later to each end of the anterior suture (Fig. 2, *3*). The Kocher clamps are then rotated inward and a continuous right angle (Cushing) suture is then placed anteriorly with no tie at either end (Fig. 2, *4*). The clamps are then withdrawn as the assistant makes traction on one end to begin the inversion. The operator completes the inversion by making traction on the other end of the anterior suture. Agglutination of the crushed

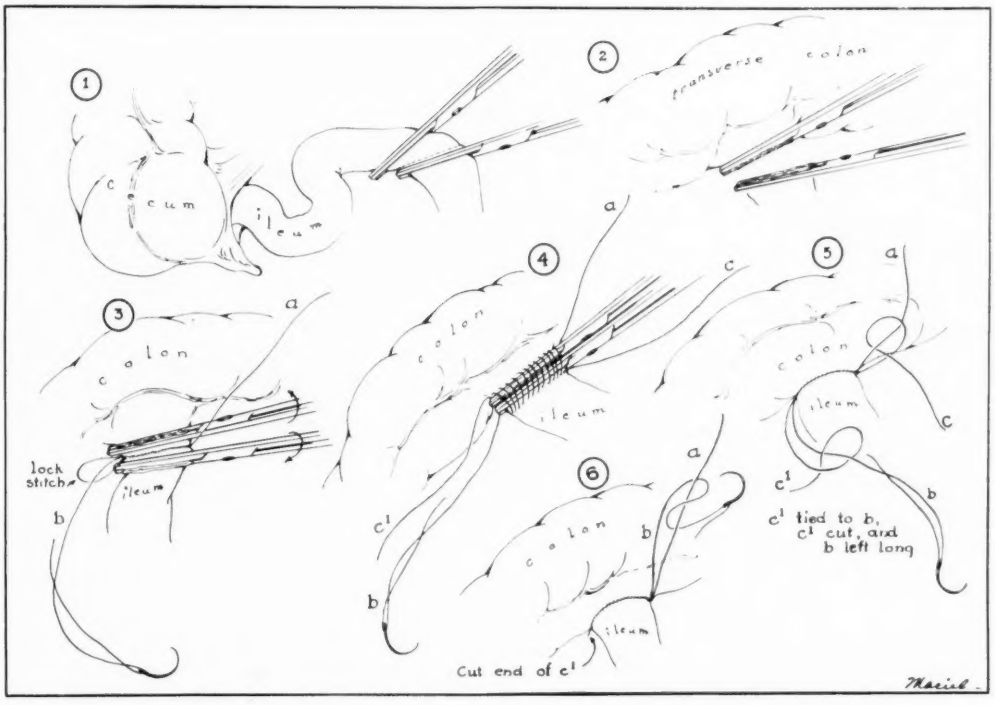

Fig. 2.—Steps in end-to-side ileocolostomy. (*1*) Division of terminal ileum. (*2*) Kocher clamp on side of colon. (*3*) Posterior continuous suture of catgut. (*4*) Anterior right angle (Cushing) suture of catgut over clamps. (*5*) Anterior suture pulled up after clamps are removed. (*6*) Posterior suture continued as second anterior layer.

ends of the bowel is depended upon to maintain closure until the inversion is accomplished. Corresponding ends of the anterior and posterior sutures are then tied (Fig. 2, *5*). The long end of the posterior suture is then continued around anteriorly and tied, forming a second anterior suture line (Fig. 2, *6*). The continuity of the lumen is established by invaginating the walls of the ileum and colon with the thumb and forefinger. The anastomosis is reinforced posteriorly and at the angles with interrupted Lembert sutures of fine silk. A portion of omentum is anchored loosely over the site of the anastomosis with fine silk and

sulfanilamide powder is dusted into the region. The same attention is directed to the mesentery and denuded area as described previously in the open type of anastomosis.

For lesions beyond the hepatic flexure, an end-to-end aseptic anastomosis is usually done. During recent years, this anastomosis has been done as a rule, using the Stone clamp. This clamp has been most satisfactory in our hands, and is the only clamp which we have tried that always seems to work well. Prior to the introduction of the Stone clamp, the anastomosis was made over straight Kocher clamps or over special clamps similar to a Kocher, but without teeth, and with the blades serrated lengthwise of the blade instead of crosswise. Extreme care is taken to remove carefully the appendices epiploicae and other fat tabs from the bowel at the proposed site of anastomosis. Only in this way can accurate, careful suture with serosal approximation be attained. Wide excision of the lesion and mesentery must be made, the cut ends must be free to come together without tension, and the blood supply must be preserved carefully to the cut ends. The clamps are usually placed somewhat diagonally so that the antimesenteric border is somewhat shorter than the mesenteric. Suture is ordinarily accomplished with a single row of Halsted mattress sutures of medium silk. After dividing the mesentery and preparing the bowel for suture, it is divided between clamps with the cautery. A row of mattress sutures is then laid posteriorly, just far enough from the clamps so that they can be pulled up and tied (Fig. 3, *1*, *2*, and *3*). The anterior row of mattress sutures is then laid (Fig. 3, *3*). A rubber-shod clamp or the rubber covered lead bar is then placed across the proximal loop to prevent bowel content from exerting pressure on the cut end of the bowel. The Stone clamps are then removed, the cautery searing being relied upon to prevent the bowel ends from opening, as described by Searff.[3] The anterior row of mattress sutures is then pulled up and tied, completing the stoma (Fig. 3, *4*). A Lembert suture of fine silk is placed between each two Halsted sutures. Serosal approximation at the mesenteric border is exceptionally important and must be obtained by careful placing of sutures. After the suture is completed, a finger must be invaginated through the anastomosis to make sure that the lumen is patent and that there is not too much of a cuff turned in. For resection and anastomosis of rectosigmoid lesions very low in the pelvis, it is important to put the clamps on in an anteroposterior direction rather than from side-to-side, and sometimes straight Kocher clamps can be used advantageously, the handles of the clamps coming out just above the symphysis pubis. In this position, two lateral rows of sutures are placed, one on the right side and the other on the left of the clamps instead of an anterior and posterior row, for low in the pelvis it is almost impossible to place a posterior row. Using this method, we have occasionally made anastomoses to the rectum below the peritoneal reflection.

It must be admitted that this entire method of aseptic end-to-end anastomosis with one row of Halsted mattress sutures is not suitable to the occasional operator or indeed to anyone who is not willing to pay attention to detail, to place each individual suture with care and precision, after careful preparation of the bowel to receive the sutures. As

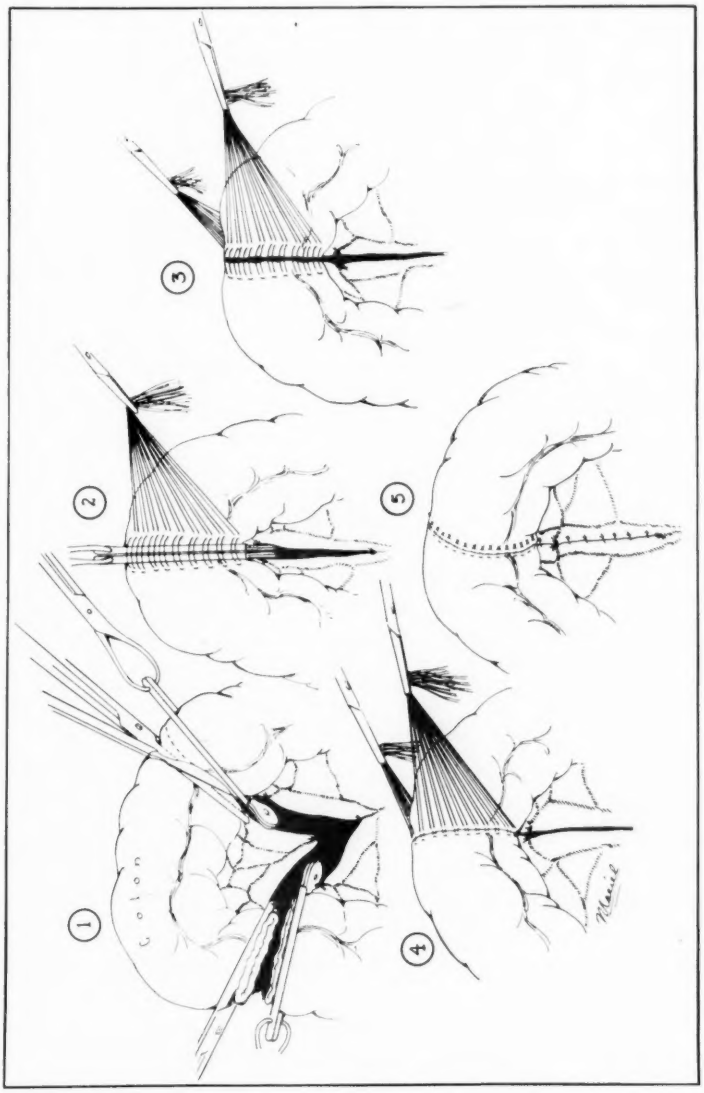

Fig. 3.—Steps in end-to-end aseptic intestinal anastomosis. (1) Division of bowel with cautery between Kocher and Stone clamps. (2) Clamps rotated and posterior layer of Halsted mattress sutures of silk placed. (3) Posterior sutures tied; anterior mattress sutures placed and clamps removed. (4) Anterior mattress sutures tied. (5) Completed anastomosis.

Halsted[4] pointed out many years ago, each suture should catch the submucosa, but not penetrate the mucosa. After completion of the suture of the bowel, the edges of the mesentery must be approximated carefully to leave no defect and no raw surfaces. Sulfanilamide powder is placed in the peritoneal cavity. The peritoneum is usually closed with continuous chromic catgut, after which the wound is washed carefully with

saline solution. The fascia is closed with interrupted figure-of-eight sutures of doubled black silk, no stay sutures being used as a rule, although here again some operators close the fascia with No. 0 or No. 1 chromic catgut, and use stay sutures in addition.

In some cases of lesions beyond the hepatic flexure, circumstances encountered at the time of resection prevented the operator from proceeding with end-to-end anastomosis. These occurred in five out of the twenty-eight cases in this group in which resection was done. In three cases great disparity in the size of the bowel proximal and distal to the lesion necessitated side-to-side anastomosis in the manner described above for right colon resections. In two of these cases a dilated proximal segment was present despite preliminary decompression by cecostomy and irrigations for thirty and sixteen days. No preliminary enterostomy had been done in the third case which presented the same problem. In two cases Mikulicz obstructive resection was employed. In one of these the sigmoid colon proximal to the lesion was filled with inspissated stool despite antecedent cecostomy and seventeen days of attempts to cleanse the bowel by irrigation. In the other, incision and drainage of an abdominal wall abscess secondary to a perforation of the transverse colon at the site of the lesion was required at the time of admission to the hospital (see Table III).

The postoperative care is important, but usually not difficult. The operation is ordinarily not accompanied by shock or loss of blood, and transfusion is often not necessary. Intravenous injection of solution of glucose or saline is given during or immediately after operation, and repeated as indicated. If a cecostomy is present, water by mouth is started immediately and soft diet as soon as tolerated. If no enterostomy has been provided, small amounts of water only are given for the first forty-eight to seventy-two hours. In some instances, especially if there have been mild obstructive symptoms, continuous gastric suction by Wangensteen's method is provided for one to two days. Exceptionally a Miller-Abbott tube has been used. In most instances, however, the patient is receiving some soft diet by the fifth to the sixth day. Mineral oil by mouth is usually started in small doses about this time, and a spontaneous bowel movement generally occurs by the seventh to ninth day.

TABLE IV

OPERATIVE MORTALITY IN CASES WITH RESECTION EQUALS 4 OF 45 CASES OR 8.8 PER CENT

	DEATHS	RESECTIONS	MORTALITY (%)
Cecum	1	7	14.2
Ascending colon	0	3	0.0
Hepatic flexure	0	7	0.0
Transverse colon	0	7	0.0
Splenic flexure	1	3	33.3
Sigmoid	2	18	11.1
Total	4	45	8.8

In the forty-five cases of resection there were four deaths, a mortality rate of 8.8 per cent divided as shown in Table IV. Two deaths were due to pneumonia and two to peritonitis.

The average hospital period for the thirty-nine patients treated by resection and immediate anastomosis and who survived was 30.8 days from resection to time of discharge from hospital. If we eliminate six patients who had prolonged hospitalization because of wound infection or other complication, the average hospital stay from the time of resection to discharge was 24.4 days. In patients in whom a cecostomy was performed, the average interval between the production of the cecostomy and resection was 15.4 days.

The follow-up information on these patients, especially those from the General Hospital, is so meager that no statement can be made regarding late results, but since the study is for the last five years only, this would not be valuable at this time. Several of the patients are known to have died with recurrence or from metastases, but the number that has survived is not known.

SUMMARY

The technique of resection and anastomosis for cancer of the colon used at the Cincinnati General Hospital has been described. The method preferred is resection and immediate anastomosis. With careful preoperative preparation and postoperative care this has led to four deaths in forty-five patients on whom resections were done, a mortality rate of 8.8 per cent.

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CARCINOMA OF THE COLON AND RECTUM

A Report of 503 Patients Treated at the Lahey Clinic 1938-1941, Inclusive

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THE fundamental principles underlying the surgical treatment of carcinoma of the colon and rectum remain the same, but the application of methods and of different operations have been constantly changing. The most conspicuous changes in the last few years seem to be, first, an increasing operability or resectability, and secondly, the wider application of one-stage operations.

Since 1929, an attempt has been made at the Lahey Clinic to standardize suitable operative procedures for lesions in different portions of the large intestine, and to utilize certain operations in a considerable group of cases in order to evaluate them. For example, over 250 two-stage abdominoperineal resections of the Lahey type were carried out and the operation evaluated. Likewise, a modified Mikulicz operation was applied to all colon malignancies, with rare exceptions, to give it a thorough trial. A consecutive series of these cases can properly serve as a basis for comparison with the one-stage operation applied to similar cases.

We have recently reviewed a series of 503 patients with carcinoma of the colon and of the rectum who were observed during the four-year period of 1938 to 1941, inclusive. The presentation of this experience gives a fairly accurate idea of the present-day treatment of these cases at the Lahey Clinic. Finally, separate consideration of the cases for 1941 demonstrates that the most satisfactory results in our experience are now being obtained.

INCIDENCE

The histories of 331 patients treated during 1938, 1939, and 1940 were reviewed in order to obtain detailed clinical data.

Table I shows the sex incidence, as follows: 191 males (60 per cent), and 140 females (40 per cent). In a previous series of our cases, we found carcinoma of the colon slightly more frequently in females and carcinoma of the rectum more commonly in males.

AGE

The youngest patient in this series was 21 years of age and the oldest was 89. The youngest patient whom we have operated upon for carcinoma of the rectum was 13 years of age. Table II, which lists the

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TABLE I

SEX INCIDENCE, 331 PATIENTS

SEX	NUMBER	PERCENTAGE
Male	191	60
Female	140	40
Total	331	100

TABLE II

AGE, 331 PATIENTS

AGE (YEARS)	NUMBER	PERCENTAGE
Below 20	0	
21-30	6	10
31-40	25	
41-50	51	
51-60	113	70
61-70	105	
71-80	30	10
89	1	
Total	331	

ages of the 331 patients in this series, shows that 10 per cent of the patients were between 21 and 40 years of age, and that a similar percentage were betweeen 71 and 80 years of age. Carcinoma of the rectum is not uncommon in young adults. In one of our series of patients, 16 per cent were found to be 39 years of age or younger.

LOCATION

There were 335 malignant lesions in these 331 patients. Thus, 4 of the group had 2 carcinomas in widely separated segments, both of which were removed at the same operation. This does not include multiple malignancies encountered in a single rectal or colonic segment where malignant degeneration was present in more than one polyp.

Arbitrary divisions are usually made of the large intestine and are by no means comparable in different reports. Two hundred and eight of the lesions (62.1 per cent) were in the rectum and rectosigmoid, while 127 (37.9 per cent) were in the colon including the sigmoidal flexure (Table III).

TABLE III

335 LESIONS, 331 PATIENTS

LOCATION OF LESION	NUMBER	PERCENTAGE
Carcinoma of rectum including rectosigmoid	208	62.1
Carcinoma of colon including sigmoid	127	37.9
Total	335	100.0

Table IV gives more detailed information concerning the distribution of the lesions throughout the colon. A consideration of the frequency of malignancy in different portions of the colon is important from the standpoint of diagnostic methods. Nearly two-thirds of all lesions encountered can be directly visualized by the sigmoidoscope or can be felt

TABLE IV

335 LESIONS, 331 PATIENTS

LOCATION OF LESION	NUMBER	PERCENTAGE
Anus	1	
Rectum	135	62.1
Rectosigmoid	72	
Sigmoid	45	
Descending colon	12	20.0
Splenic flexure	10	
Transverse colon	17	5.1
Hepatic flexure	10	
Ascending colon	12	12.8
Cecum (appendix 2)	21	
Total	335	100.0

by digital examination. The remainder can be indirectly visualized by means of a barium enema.

DURATION OF SYMPTOMS

A malignant lesion in the large intestine may be present for some time before symptoms result. Certainly a polyp or polypoid lesion may be present for many months or years without symptoms or with intermittent symptoms. The duration of symptoms in this group of patients is shown in Table V. Many of the patients having symptoms over 2 years may have had symptoms previous to malignant degeneration of the polyp. It is encouraging to find that 60.7 per cent of the patients had symptoms of less than 1 year's duration, and approximately 40 per cent of less than 6 months' duration. This is a considerable improvement, since in previous series of our cases the average duration of rectal lesions was 9 months and of colonic lesions 11 months.

TABLE V

DURATION OF SYMPTOMS, 331 PATIENTS

DURATION	NUMBER	PERCENTAGE	
Under 1 mo.	17		
1-3 mo.	49	38.4	
3-6 mo.	61		60.7
6-12 mo.	74		
1-2 yr.	60		36.3
Over 2 yr.	60		
Not certain	10		3.0
Total	331		100.0

EXTENT OF LESION

During the years 1938 to 1940, inclusive, 280 resections of the large intestine were performed in the 331 patients observed (Table VI). The extent of the lesion was determined by observation at the time of operation and by the pathologist's report of the gross and microscopic appearance. In 103 patients (36.8 per cent) the carcinoma showed no evidence of spread, remaining in situ at its point of origin. Thus, ap-

TABLE VI

280 RESECTIONS, 331 PATIENTS

EXTENT OF LESION	NUMBER	PERCENTAGE
Primary site in bowel only	103	36.8
Involvement of lymph glands	112	40.0*
Blood vessel invasion	89	31.8*
Invasion of other organs	62	22.2*
Liver metastasis present upon resection	27	9.6

*Many duplications.

proximately one-third of the patients fell into a most favorable group for possible cure. Invasion of other structures, such as the small intestine, parietes, and pelvic organs, was observed in 62 (22.2 per cent). Liver metastasis was present at the time of resection in 27 (9.6 per cent). Blood vessel invasion observed upon examination of microscopic slides was found in 89 (31.8 per cent). Involvement of regional lymph nodes determined by microscopic examination occurred in 112 (40 per cent). Obviously, more than one type of involvement sometimes was present, as blood vessel invasion usually was observed in those patients with liver metastasis and in a few of those with regional lymph node involvement.

OPERABILITY

As mentioned earlier in this communication, one of the striking changes in the management of carcinoma of the colon and rectum has been an increasing operability or resectability. For comparison of different series of cases, it is important to know the proportion of patients with these lesions who are submitted to resection. If only favorable cases are accepted for radical surgery, the result will be much more satisfactory than otherwise. The benefits of radical surgery for favorable lesions are generally acknowledged. The results of resection for unfavorable and extensive lesions are less well known; however, from our experience at the clinic, we believe that many patients, although they do not have a chance for cure, receive sufficient benefit to justify the procedure. The operability in any series of cases depends upon the extent of the lesion and the presence of local or distant spread. The condition of the patient may be such that resection is not justified and quite properly the experience of the surgeon in a large measure will determine his operability. If the surgeon's experience with favorable cases is satisfactory, then he is justified in accepting less favorable cases with a reasonable prospect of performing the resection with at least temporary success.

During the 4-year period, 1938 to 1941 inclusive, 503 patients with carcinoma of the colon and rectum were observed (Table VII). No patients were excluded from this series because of poor condition or obvious generalized metastasis on examination. Four hundred and twenty had some type of resection, making an operability or resectability rate

TABLE VII

OPERABILITY, 503 PATIENTS

YEAR	RESECTION	NO RESECTION*	TOTAL
1938	88	22	110
1939	117	16	133
1940	75	13	88
1941	140	32	172
1938-1941	420 (83.5%)	83 (16.5%)	503 (100%)

*Includes palliative operations and unoperated cases.

of 83.5 per cent. Eighty-three patients did not have resection, but had either some form of palliative operation, such as colostomy or intestinal anastomosis around the lesion, or had no operation.

SELECTION OF OPERATION

Four different operations of the resection type were performed for carcinoma of the rectum and rectosigmoid. A one-stage abdominoperineal resection (Miles) was considered the operation of choice for all these lesions, and was performed in good-risk patients of any age. During the 4-year period, 58.5 per cent of patients were operated upon by this method, whereas in the final year of this period (1941) the percentage was 76.7.

A one-stage anterior or abdominal resection was performed in 5.9 per cent. This operation is similar to the Miles resection except that a small rectal stump is left in place. In my opinion, this operation is rarely indicated, since these patients can be submitted to the one-stage abdominoperineal resection. In the few cases in which it was utilized, the lesion was in the high rectosigmoid.

The two-stage abdominal resection (Lahey) was employed in 30.4 per cent, being used for poor-risk patients, some with moderate obstruction, and for all patients who had perforated lesions with abscess. This procedure was also used for doubtfully operable patients, particularly those with marked adherence, in whom it was impossible to tell whether the cause was inflammation or extension of malignancy.

A two-stage resection consisting of a loop colostomy and subsequent perineal excision was employed in 5.2 per cent. This was used for low rectal lesions in poor-risk patients, particularly those who were unusually obese or who had complicating conditions of cardiorenal or pulmonary origin.

A two-stage modified Mikulicz resection was performed in all carcinomas of the colon during this 4-year period.

The number and percentage of these five different operative procedures are shown in Table VIII. There were 287 rectal resections, 64.4 per cent of which were done in one stage, and 35.6 per cent in two stages.

TABLE VIII

TYPE OF OPERATION, 420 RESECTIONS

	NUMBER	PERCENTAGE	
Rectal:			
One-stage operation:			
Abdominoperineal resection (Miles)	168	58.5	
Anterior or abdominal resection	17	5.9	
	185	64.4	
Two-stage operation:			
Abdominoperineal resection (Lahey)	87	30.3	
Colostomy and perineal resection	15	5.3	
	102	35.6	
Total			287 (100%)
Colonic:			
Mikulicz resection	133		
Total			420

PREPARATION FOR OPERATION

A short period of preoperative preparation was the rule. If no obstruction was present on admission, a single dose of 1.5 to 2 ounces of 50 per cent solution of magnesium sulfate was given, followed by colonic irrigation morning and evening until operation. No irrigation was given the morning of operation, and the saline purge was not repeated except in exceptional cases. Less than 5 per cent of patients had a preliminary cecostomy. Only a few patients in this series were prepared by the use of sulfaguanidine, and the administration of the sulfonamide drug was not continued. Patients were kept on a high caloric, low residue diet during the preoperative period, and received blood transfusions as indicated. Routinely, a one-stage abdominoperineal resection for carcinoma of the rectum was performed three days after admission to the hospital if no obstruction was present. A modified Mikulicz operation was carried out after a similar interval.

ANESTHESIA

All patients in this series, irrespective of age or general condition, were operated upon under spinal anesthesia. The routine spinal anesthetic agent was pontocaine weighted with 10 per cent glucose solution, utilizing 14 to 20 mg. of the drug. In a few patients, nupercaine in 1:1,500 dilution was used. Some of the patients with lesions complicated by extension were operated upon under fractional or continuous spinal anesthesia. Spinal anesthesia was supplemented at times by avertin, pentothal sodium, or cyclopropane anesthesia. We feel sure that spinal anesthesia administered by an experienced anesthetist offers the best possible operating conditions and is particularly valuable in the more complicated cases.

TABLE IX

OPERATIVE MORTALITY, 503 PATIENTS

TYPE OF OPERATION	CASES	DEATHS	PERCENTAGE
Miles resection	168	11	6.5
Lahey resection	87	12	13.8
Perineal resection	15	3	20.0
Anterior resection	17	4	23.5
Mikulicz resection	133	15	11.3
Total resections	420	45	10.7
Palliative operations	83	19	22.9
Total all operations	503	64	12.7

TABLE X

45 DEATHS, 420 RESECTIONS

CAUSES OF DEATH	NUMBER	
Peritonitis	8	Infection
Gas bacillus	2	
Wound separation	4	
Pneumonia	6	
Pulmonary embolus	5	
Myocardial failure	3	
Intestinal obstruction	4	
Mesenteric thrombosis	3	
Uremia	4	
Cerebral thrombosis	2	
Surgical shock	1	
Agranulocytosis	1	
Not determined	2	
Total	45	

TABLE XI

END RESULTS, 162 RESECTIONS*

(1932-1936, Inclusive)

NO. PATIENTS		PERCENTAGE
75 survived 5 years plus		46.3
22 died post-operatively	13.5	53.7
65 died of recurrence	40.2	
140 survived operation, 5-year cure		53.6

*All patients were followed for 5 to 10 years.

TABLE XII

PRESENT-DAY MANAGEMENT, 172 PATIENTS (1941)

TYPE OF RESECTION	CASES	PERCENTAGE	DEATHS	PERCENTAGE
Miles	79	76.7	3	3.8
Anterior	5	4.8	1	20.0
Lahey	15	14.5	1	6.7
Perineal	4	3.9	1	25.0
Mikulicz	37		1	2.7
Total resections	140	81.4	7	5.0
Palliative operations	32	18.6	3	9.4

OPERATIVE MORTALITY

The operative mortality following the different types of operation is shown in Table IX. Without selection of cases, 420 resections were carried out, with 45 operative deaths, a total percentage mortality of 10.7. One hundred and sixty-eight patients had a one-stage abdominoperineal resection, with 11 deaths (6.5 per cent). The mortality was double this figure following the two-stage abdominoperineal resection of the Lahey type, this group of patients having more extensive and complicated lesions and consequently a higher operative risk. In 87 patients, 12 deaths occurred. A high mortality also followed perineal resection in a small, poor-risk group of patients, 3 deaths occurring in 15 operations (20 per cent). There were 133 Mikulicz resections with 15 deaths, a mortality of 11.3 per cent. Nineteen deaths followed palliative procedures. Not all the 83 patients listed were operated upon, so the mortality after palliative procedures was more than double that for the group having resection.

There was no selection of cases in determining operative mortality after the 420 resections. Approximately 10 per cent of these patients had liver metastasis at the time of resection. Likewise, 22 per cent including those having liver metastasis had definite invasion of other structures. If one separates the curable cases from the incurable, the operative mortality is materially improved; however, the only fair way to present one's experience with resection is to include all cases in which resection was performed.

The causes of the 45 deaths in 420 patients having resection are shown in Table X. Twenty were due to infection, 8 having peritonitis as a cause of death. Sulfanilamide was used in 5 to 10 Gm. amounts in the peritoneal cavity when gross soiling occurred. When no gross soiling occurred in the peritoneal cavity but did occur in the dissection of the rectum posteriorly, sulfanilamide was put in the presacral space. Except for a small series of cases, no sulfonamide drugs were used in preoperative preparation, and none in the peritoneal cavity in clean cases. The other causes of death, such as pulmonary embolism, cardiac failure, and obstruction, are what one would expect in any large group of serious abdominal procedures.

END RESULTS

I have attempted to evaluate the results following resection for carcinoma of the colon and rectum. Obviously, the series of 503 cases during the years 1938 to 1941, inclusive, cannot be used. Consequently, a previous series of 162 consecutive resections performed during the years 1932 to 1936, inclusive, was reviewed (Table XI). Seventy-five of the entire group of patients submitted to resection survived between 5 and 9 years, a survival rate of 46.3 per cent. Twenty-two patients died postoperatively, and 65 died subsequently of recurrence

of the carcinoma. Thus, 53.7 per cent had an unsatisfactory result. Presumably a certain proportion of those who did not survive operation had favorable lesions. Of the 140 patients who survived the operation, 53.6 per cent showed no evidence of recurrence for the 5- to 10-year period during which they were observed.

PRESENT-DAY MANAGEMENT

A review of our experience during 1941 gives a clear picture of our present practice in the treatment of carcinoma of the colon and rectum. During the year 1941, 172 patients were seen in consultation (Table XII). One hundred and forty (81.4 per cent) were submitted to resection, with 7 operative deaths, a mortality of 5 per cent. This again was an unselected group of cases, including all patients in whom the diagnosis of carcinoma was made, irrespective of the condition of the patient or extent of the lesion. Seventy-nine one-stage abdominoperineal resections were performed, with 3 deaths, a mortality of 3.8 per cent. Thirty-seven consecutive Mikulicz resections were performed, with 1 death, a mortality of 2.7 per cent. In summary of the year 1941, an operability rate of 81.4 per cent was maintained. A one-stage abdominoperineal resection was performed in 76.7 per cent of the rectal carcinomas, with a mortality of 3.8 per cent, and the modified Mikulicz resection, which at the Lahey Clinic is considered the operation of choice for carcinoma of the colon, was performed with a mortality of 2.7 per cent.

THE MANAGEMENT OF POLYPS OCCURRING IN THE RECTUM AND COLON

VERNON C. DAVID, M.D., CHICAGO, ILL.

IT HAS fallen to my lot to examine and care for more than one hundred patients having polyps of the colon and rectum and this article will indicate some reactions to the problems involved.

Areas of hyperplasia, pedunculated adenomas, and sessile papillomas are common tumors in the colon. Feyrter found 1,100 such lesions in 1,800 consecutive autopsies. Fifty per cent of carcinomas of the colon and rectum studied were found to have flat, raised areas of hyperplasia in close proximity to them. Twenty-five per cent of carcinomas of the colon and rectum have been found to have adenomas accompanying them. The earliest carcinomas of the large bowel I have seen are those occurring on the periphery of pedunculated adenomas where, as a rule, the most bizarre arrangement of epithelium is seen. Multiple polyposis of the colon where hundreds of adenomas, small papillomas, and areas of hyperplasia are seen is frequently the seat of multiple carcinoma. Prolonged ulcerative colitis where inflammatory mucous polyps are often seen is complicated by carcinoma in about 5 per cent of the cases.

For these reasons it is obvious that all hyperplastic areas, adenomas, or papillomas should be removed or completely destroyed whenever possible because they constitute a definite precancerous lesion. The transition from hyperplasia to adenoma or papilloma formation to carcinoma is difficult to define or to recognize.

From a clinical viewpoint, hyperplasia of the bowel mucosa gives no symptoms and is found in the course of proctoscopic examinations, in examination of surgically removed segments of bowel, or at autopsy. Adenomas, which vary from the size of a BB shot to a walnut, make their presence known by bleeding, protrusion from the rectum if they are low in the bowel, and cramplike pains due to attempts of the bowel to push them along, and occasionally by becoming an apex of an intussusception.

The bleeding may be slight and may be bright or dark depending on the location of the adenoma, the blood obviously being brighter the lower the growth is in the bowel. The bleeding may occur without a bowel movement, and in some instances has been as much as a pint of blood.

The symptoms of villous tumors or papillomas, which may be small or as large as an apple, are much the same as adenomas except that they are usually associated with the passage of a large amount of mucus due

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to the presence of many goblet cells in waving branches of the tumor. As much as a pint of mucus may be passed in a day. They may also reach a size that produces obstruction of the bowel.

Multiple polyposis of the colon is frequently associated with severe loss of blood inducing profound anemia, diarrhea, and malnutrition. Carcinoma, frequently multiple, developing in the colon at the site of various polyps, can alter the symptoms by producing obstruction and metastases.

Inflammatory polyps, which accompany long-standing amoebic dysentery or ulcerative colitis, may be the result of massive hyperplasia of islands of mucosa between areas of ulceration, or they may be very difficult to distinguish from true adenomatous tumor formation. The transition of these benign polyps to carcinoma is by no means a rarity.

Many of these various polypoid changes in the membrane of the large bowel are found by proctoscopic examinations in a search for the cause of bleeding or change of bowel habits. In children, the protrusion of a pedunculated adenoma on defecation is not uncommon. Where the search for the cause of bleeding from the large bowel results in normal proctoscopic findings and a negative fluoroscopy of the colon, an adenoma or papilloma must be suspected. Many such lesions can be demonstrated by the double contrast enema, using barium and air injection, and making stereoscopic films. It is necessary to repeat this examination to be sure that the defect found in the first examination is present in subsequent examinations. The site of the defect of an adenoma may vary six to eight inches because of the long pedicle of normal mucosa that many of the adenomas develop. Continued bleeding from a colostomy following resection of the large bowel for carcinoma should excite suspicion of the presence of an adenoma in the remaining bowel, frequently. Double contrast enemas will demonstrate them.

There are many patients with persistent bleeding of red blood where polypoid tumors of the large bowel are suspected but cannot be found despite repeated careful examinations. As a general rule, exploratory operations in such patients are not justified as it is extremely difficult to find adenomas of the bowel by palpation unless they are fairly large or a definite part of the bowel is under suspicion. Dixon has used transillumination at the time of operation to demonstrate such intraintestinal lesions. Other lesions presenting much the same type of bleeding are Meckel's diverticulum containing gastric mucosa, adenomas of the small bowel, malignancies of the small bowel, or localized granulomatous ulceration of the colon.

In the treatment of these polypoid lesions of the large bowel, thorough removal by the safest and simplest method is the underlying principle.

Pedunculated adenomas which prolapse or can be prolapsed through the anus are removed by ligation of the pedicle well away from the adenoma.

Pedunculated adenomas which can be seen through the proctoscope can be removed safely by thorough fulguration of the pedicle through a proctoscope using a long fulguration wire enclosed in a ureteral catheter. Areas of hyperplasia can be similarly removed by fulguration.

Flat adenomas of the rectum below the peritoneal reflection can be fulgurated and carbonized with safety.

Careful inspection of adenomas should be the rule to be certain there is no evidence of ulceration of the tumor and no induration which can be determined by palpation or by manipulation of the polyp by the end of the proctoscope. Either ulceration or induration makes one suspicious of malignancy and several small areas should be removed for biopsy. I am personally a firm believer in the most radical operation for all carcinomas no matter what the size because of the impossibility of estimating with accuracy the tendency to metastases in any individual tumor.

In large pedunculated or flat adenomas above the peritoneal reflection there is an indication to prepare the patient carefully by complete emptying of the large bowel and examination of the tumor through a laparotomy incision. If no signs of malignancy such as induration or dimpling of the bowel at the site of the tumor attachment is present, the tumor can be removed as polyps are removed in any part of the colon. If the polyp is movable and therefore pedunculated, the tumor is grasped between the thumb and index finger in an area where the polyp has the greatest mobility within the bowel, small stomach clamps are applied on the bowel above and below the polyp, and after the field is surrounded with moist pads, the polyp is held firmly as indicated and a small incision made through the longitudinal muscle band opposite the mesenteric attachment, and the polyp is extruded (Fig. 1). The pedicle is ligated well away from the polyp and the bowel wall is closed with three layers of fine silk, the outer layer attaching an appendix epiploica over the suture line (Fig. 2). Gloves and instruments are changed for abdominal closure.

If the polyp is a sizable sessile attached adenoma or papilloma, a bowel resection is the operation of choice. Because of its safety I favor the Rankin obstruction type of resection, leaving the Payr clamps on for twenty-four hours, applying a spur crusher when they are removed, and closing the colostomy under local anesthesia in two to three months. Mortality with this type of operation has been nil in over twenty patients.

Another problem in removal of these tumors is presented when large sessile papillomas not suitable for fulguration occur in the ampulla of the rectum. They are difficult to approach from above or below un-

less one decides to remove the rectum, which in my opinion is not necessary in the tumors which are benign. There again induration or ulceration as well as biopsy makes the decision as to their benignancy. In fifteen cases the operation depicted in the illustration by Shepard was carried out. The rectum is split open up to the coccyx (Fig. 3). The tumor is grasped by Allis forceps and gently pulled downward, intus-

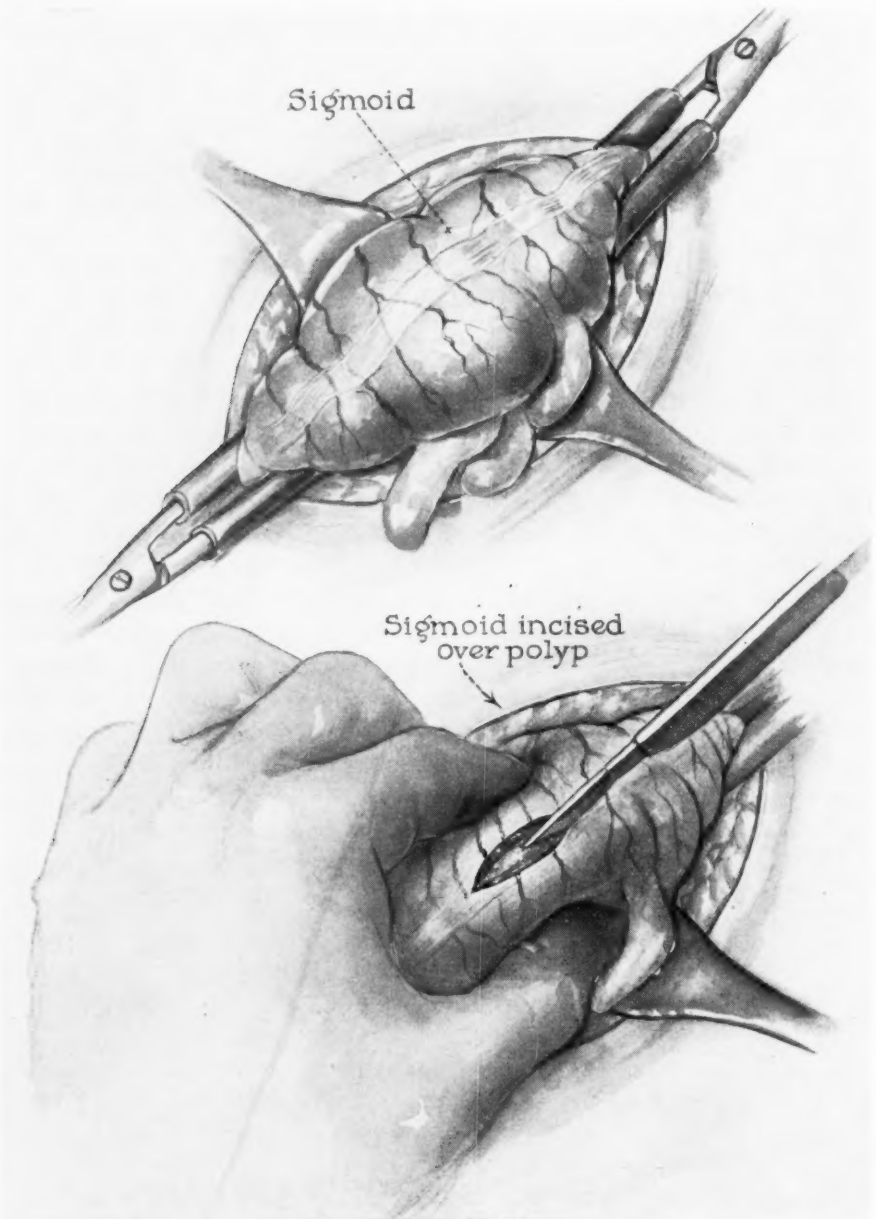

Fig. 1.—Sigmoid containing the polyp held with the bowel in the grasp of stomach clamps; bowel is opened over the polyp.

suscepting the bowel mucosa. The normal, healthy mucosa surrounding the tumor is picked up by Allis forceps, to prevent retraction of the mucosa, and the tumor is completely removed by the cutting cautery going through the submucosa. Bleeding points are ligated and a running stitch of catgut approximates the mucosa on both sides of the defect. In a few instances a complete circumferential cuff of mucosa was removed with end-to-end suture without seriously narrowing the lumen of the bowel which is normally wide in this region.

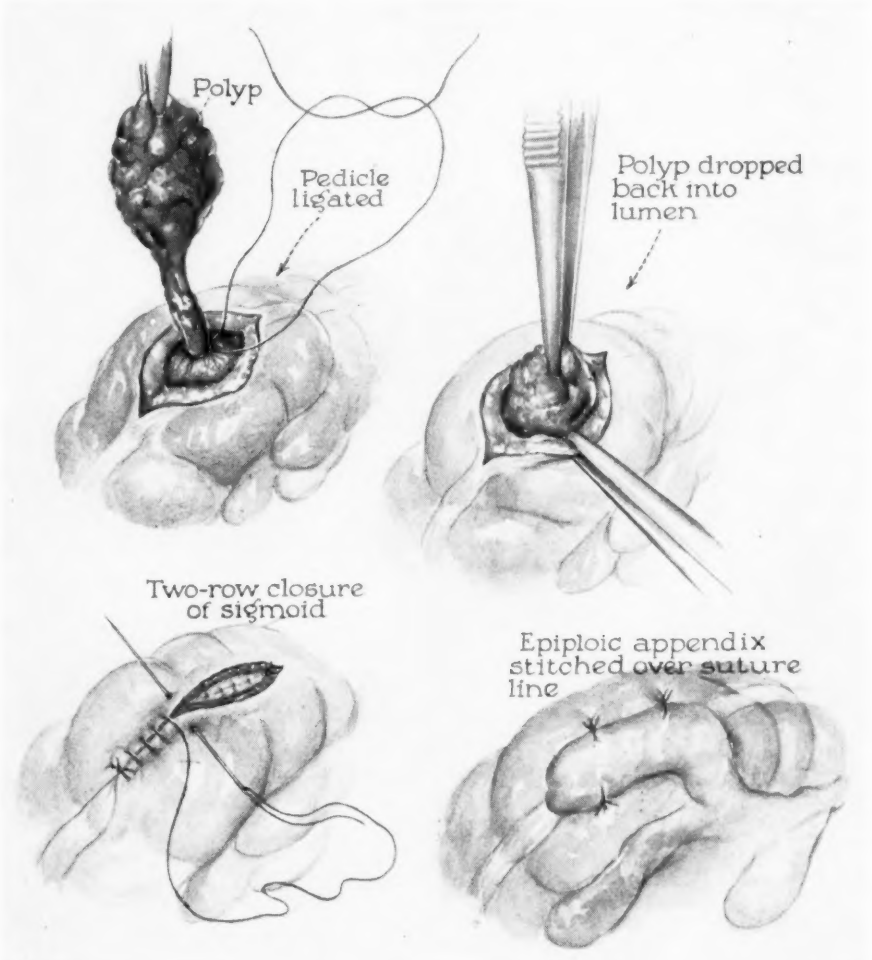

Fig. 2.—Ligation of the pedicle of the polyp; closure of the bowel wall in layers with fine catgut.

The completely incised bowel wall is then closed with fine catgut, taking care not to place sutures through the mucosa which would serve as avenues of infection from the lumen of the bowel (Fig. 4). The stitches are placed in the submucosa, which tends to invert the mucosa

into the lumen of the bowel. The muscularis is then sutured with interrupted catgut and a third row of stitches is placed through the areolar tissue over the bowel, which includes the extensions of the external sphincter muscle to the coccyx. The external sphincter muscle is united

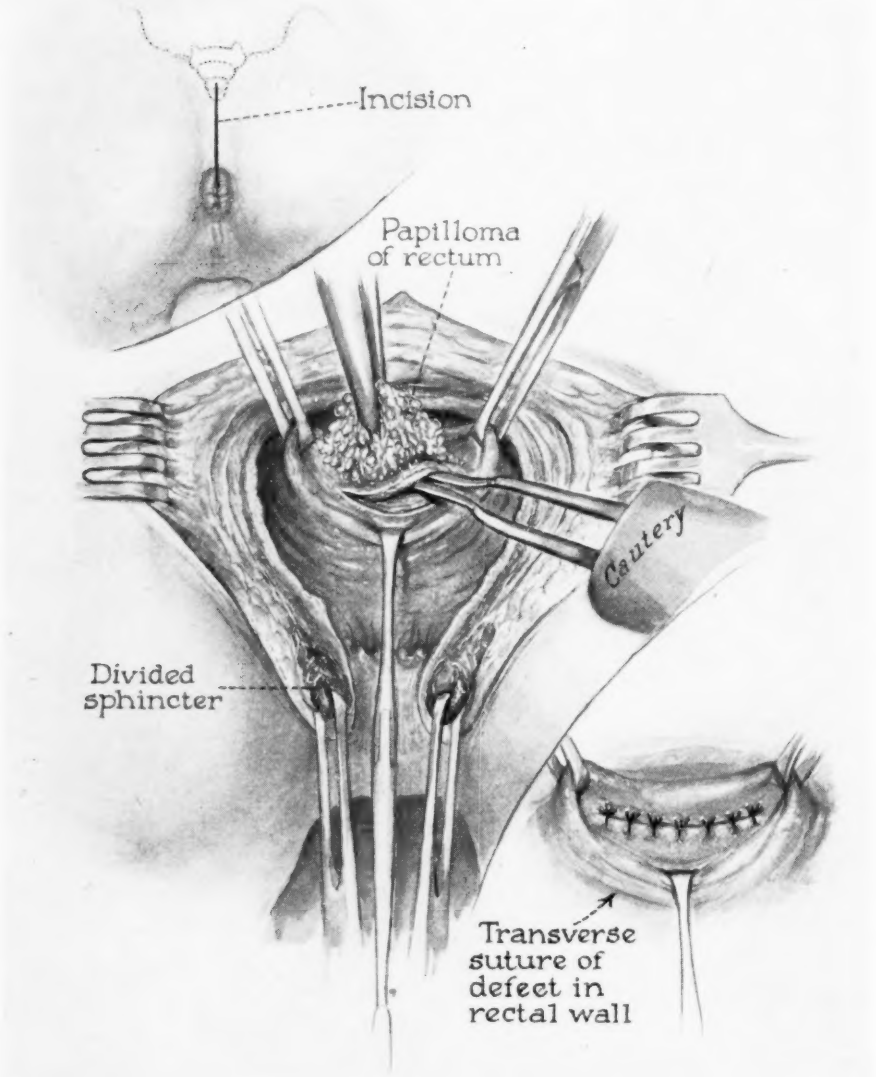

Fig. 3.—Operation for removal of sizable benign lesions in the ampulla of the rectum showing the incision, removal of the growth, and suture of the mucosa.

separately by two interrupted mattress stitches of catgut. The remaining wound is sprinkled with sulfanilamide crystals, and a vaselined piece of gauze is applied to cover the wound. The bowels are moved on

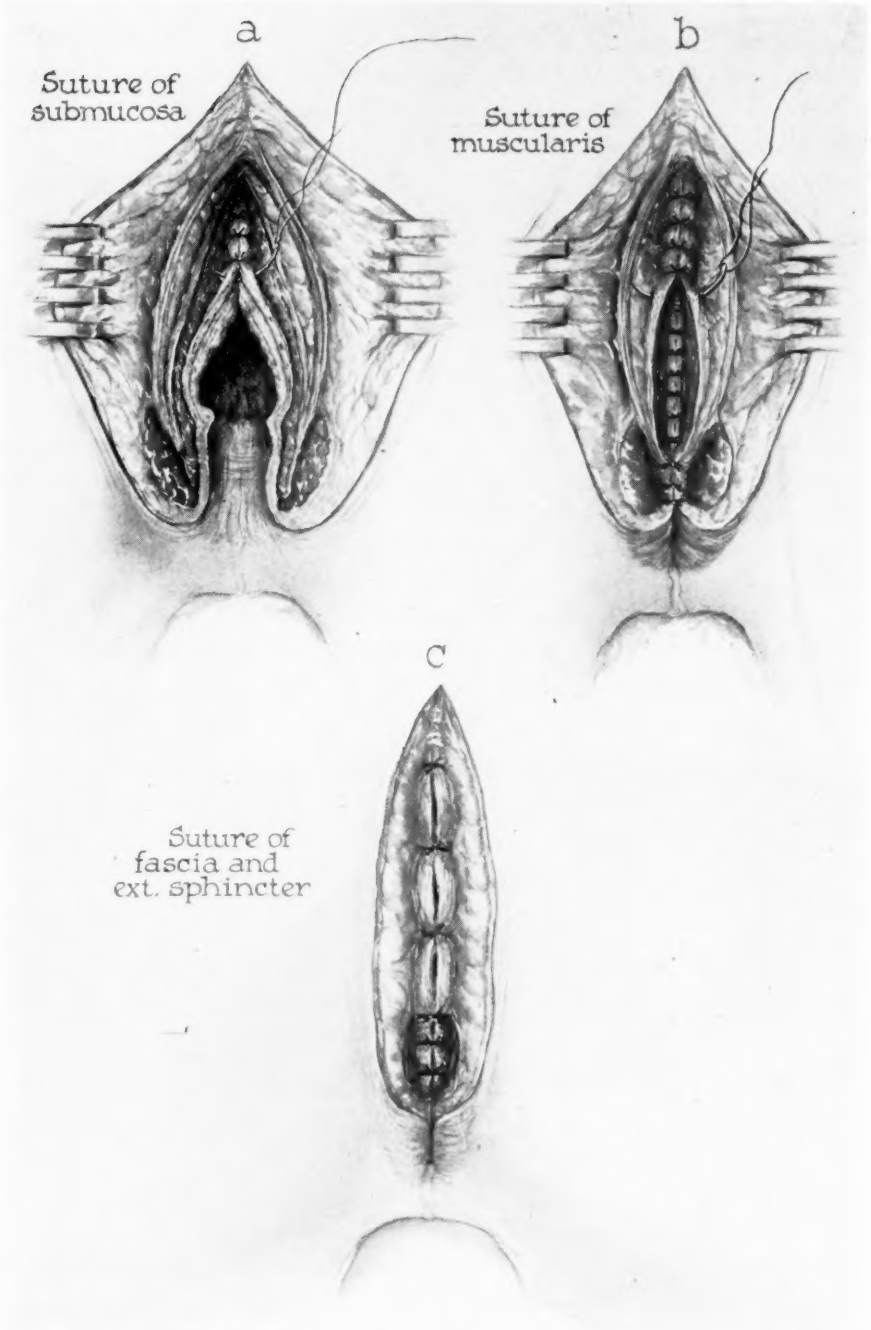

Fig. 4.—(*a*) Suture of the bowel by interrupted catgut stitch going through the submucosa; (*b*) suture of the muscularis of the bowel; (*c*) suture of the sphincter and interrupted sutures through the extension of the sphincter muscle to the coccyx.

the third or fourth day by an oil and water enema. There is some leakage along the suture line about the sixth day but in all of the patients healing has taken place without a fistula, with continence of the sphincter muscles, and to date no patient has developed carcinoma at the removal site of the papilloma. One patient had a small local recurrence of the papilloma which was cured by fulguration. He has been well and without recurrence for over five years.

Multiple polyposis of the colon is a distressing lesion and because of the frequency of the development of malignancy should be treated by a graded removal of the colon. If the rectum is the site of but a few polyps, they may be fulgurated and destroyed and eventually an ileosigmoidostomy performed.

Multiple inflammatory polyps occurring in ulcerative colitis are an indication for ileostomy and colectomy due to the danger of malignancy developing in them. If one or two polyps develop following amoebic dysentery or ulcerative colitis, they may be treated as outlined for polyps of noninflammatory origin.

In summary, it should be emphasized that polyps of the colon and rectum should be radically destroyed or removed due to their tendency to malignant degeneration. Many can be handled well by fulguration and local removal but where necessary more radical surgery is indicated and should be done.

A NEW PRACTICAL SIGMOIDOSCOPE

CECIL P. G. WAKELEY,* C.B., D.Sc., F.R.C.S., F.A.C.S., HANTS, ENG.

FOR more than a year I have been using a coldlite sigmoidoscope which has some very definite practical advantages over all other forms of instruments. Coldlite solves the problem of introducing cold-light inside the body without danger, glare, or electric shock and is especially useful in illuminating cavities.

Hitherto made in solid form only as retractors, specula, or tongue depressors, tubular instruments such as sigmoidoscopes and proctoscopes have now been produced.†

The main features of the sigmoidoscopes (Fig. 1) are that the source of light is placed outside the tube, allowing an unobstructed view, freedom of operation, and safe use of diathermy instruments as the material is a perfect nonconductor of heat and electricity. The cold light travels along the wall of the instrument and escapes at the distal end showing the object under examination in a plastic form and natural coloring.

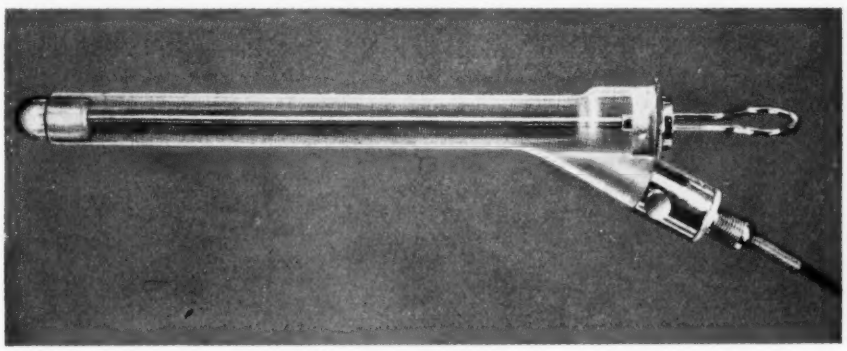

Fig. 1.—Coldlite examination and operating sigmoidoscope with airtight window for inflation and light attachment. (Brit. Pat. Appl. No. 5257/42.)

I have had made a stainless steel inspection mirror with a graduated stem (Fig. 2) for use inside the sigmoidoscope. Ulcers, polypi, fissures, and carcinomas can be detected at an early stage with the aid of the mirror, as they can be easily seen through the walls of the sigmoidoscope, greatly facilitating an early and accurate diagnosis.

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†The instrument is made in two sizes, 13/16" and 15/16" external diameter by Messrs. Vann Bros., 63 Weymouth Street, London, W. I. England.

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A further advantage is that once the instrument is introduced the complete examination can be carried out by moving the mirror inside the tube, thus eliminating discomfort to the patient.

Fig. 2.—Stainless steel inspection mirror, graduated stem.

For all practical purposes unbreakable, sterilizable by boiling, this instrument has proved a valuable addition to the surgeon's examination equipment.

ANTERIOR RESECTION OF THE RECTOSIGMOID AND UPPER RECTUM WITH RE-ESTABLISHMENT OF CONTINUITY

LAURENCE SIDNEY FALLIS, M.D., F.R.C.S.
(From the Department of General Surgery, Henry Ford Hospital)

RESTORATION of continuity of the intestinal tract after removal of carcinoma of the rectum has long attracted the attention of surgeons. Many of the earlier perineal procedures for excising rectal carcinoma such as the operations of Hochenegg, Kocher, Allingham, and others aimed at reuniting the bowel and preserving the sphincteric apparatus.

This period in the development of the surgery of rectal cancer ended with Miles' convincing demonstration of the undeniable superiority of his radical combined abdominoperineal operation. Vastly improved end results, and freedom from complications and annoying sequelae eventually led to the almost complete abandonment of other measures for the eradication of rectal and rectosigmoid malignancies. Miles based his operation on the concept that carcinoma of the rectum spread in all directions, upward, downward, and laterally. However, the more recent studies of regional glandular metastases in carcinoma of the rectum by Coller and co-workers,[1] and Gilchrist and David[2] indicate that glandular metastasis is upward in the great majority of instances. This observation raises the point that the combined operation may be unnecessarily radical in low sigmoid and rectosigmoid carcinomas and has led to a limited revival of operations in which the low rectum levatores and muscles and the sphincteric apparatus are not sacrificed. Horsley,[3] Devine,[4] Pratt,[5] Dunphy,[6] and Dixon[7] and others have all made contributions to this effect.

The one-stage combined abdominoperineal operation of Miles still remains the operation of choice for most cancers of the rectum and rectosigmoid. Under certain circumstances which more or less may be defined, departure from this universally adopted procedure is permissible. Anterior resection of the rectum with or without restoration of continuity is an alternative method of dealing with tumors of that ill-defined region, the rectosigmoid. The great difficulty in having anything to do with operations for rectal carcinoma which do not require permanent colostomy is that the surgeon will be tempted to extend the scope of selection of cases to include those patients that should be subjected to more radical procedures. The temptation to make re-establishment of continuity the sole objective of the operation is one that must constantly be guarded against if the surgeon is to avoid that most grievous of surgical sins, namely, fitting the patient to the operation rather than the operation to the patient.

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INDICATIONS FOR ANTERIOR RESECTION

1. Operation of choice in tumors of the low sigmoid
2. As a matter of expediency in certain poor-risk patients
3. As a substitution for the classical abdominoperineal operation in cases of borderline operability
4. When permanent colostomy is refused

Tumors of the Low Sigmoid.—Tumors involving the sigmoid just proximal to the peritoneal reflection always present problems in management. Exteriorization, often impossible because of obesity, shortened mesentery, etc., does not permit the removal of enough mesentery to satisfy the requirements of a radical operation because the inferior mesenteric and superior hemorrhoidal vessels must be left intact in order to preserve nutrition of the distal loop. The sigmoid arteries with the adjacent mesentery can usually be removed, but since the lymphatic radicles from this area drain into the lymphatic chain running with the superior hemorrhoidal and inferior mesenteric arteries, it is imperative to remove these vessels if a radical resection is to be performed. It is true that the combined abdominoperineal operation fulfills this requirement, but in many instances it is unnecessarily radical, for the lymphatic drainage in this region is largely upward rather than downward or lateral. The operation of anterior resection of the rectum is ideal in this location since it permits removal of the portion of bowel containing the tumor together with adequate removal of mesosigmoid and mesorectum with their contained blood and lymphatic vessels.

Poor-Risk Patients.—Anterior resection of the rectum may be utilized as a matter of expediency in certain poor-risk patients who in spite of careful preparation and adequate support are standing operation poorly. When it is evident that it is not prudent to continue with a proposed abdominoperineal resection the operation can be terminated at once by sectioning and closing the rectum below the tumor and exteriorizing the upper loop and the tumor.

Palliative Operations.—Palliative resection of the rectum for lesions involving the rectosigmoid or upper rectum in the presence of local extension of the disease, enlarged lymph nodes along the aorta, or a single demonstrable liver metastasis is now recognized as a justifiable procedure. Many lives have been prolonged for months in relative comfort by adopting the attitude of removing all resectable tumors even in the presence of known metastases. Life may be made still more tenable for those unfortunates if the surgeon chooses to restore continuity of the intestinal tract by adopting the operation of anterior resection.

When Colostomy Is Refused.—It has been claimed that when a patient refuses colostomy it is because of poor presentation by the surgeon or medical adviser. Nevertheless, there is a small group of patients who will flatly refuse any operative procedure which will necessitate a permanent colostomy. With them it is a question of either no colostomy or no operation. The surgeon faced with this problem has some justifica-

tion in carrying out what is admittedly a less radical procedure which might be curative rather than condemning the patient to a certain fate.

PREOPERATIVE PREPARATION

Under local anesthesia a transverse incision is made cutting across the right rectus muscle midway between the umbilicus and the costal margin and separating the fibers of the posterior rectus sheath in the line of the incision. A loop of underlying colon is delivered into the wound and held in position by a glass rod thrust through its mesentery. Since the operation requires only a few minutes, there is minimal disturbance, and the patient becomes ambulatory in two or three days. Transection of the bowel produces complete defunctionalization.

Daily irrigations of the distal segment with antiseptic solutions including suspensions of zinc peroxide over a two-week period reduce the bacterial count of the colon and the inflammatory elements of the tumor. At the same time the general condition of the patient is built up with a high protein diet, vitamin C administration, and blood transfusion when indicated.

ANESTHESIA

Unless contraindicated, spinal anesthesia with dilute nupercaine solution 1:1500 is the anesthetic of choice, although a combination of general and local anesthesia will be satisfactory if the transverse incision is used.

INCISION

One of the chief difficulties of the operation is the depth in the pelvis at which the anastomosis must be carried out. The use of a modified transverse incision recently described by Cherney[8] is of inestimable value. This curved incision runs across the lower abdomen in the pubic hairline from a fingerbreadth below one anterior superior spine line to the same point in the opposite side. The anterior sheath of both rectus muscles and some of the aponeurosis of the external oblique muscles are cut in the line of the incision. The lower flap of rectus sheath is then turned down to the pubic spine where the rectus and pyramidalis on both sides are detached from the pubic crest and turned upward. The peritoneum and transversalis fascia are cut in the line of the incision. The exposure is perfect and the wound is easily closed. The abdominal wall heals soundly.

OPERATIVE TECHNIQUE

With the abdomen opened, the patient in the Trendelenburg position, and the small intestines packed away, the operation proceeds along conventional lines with regard to mobilization of the portion of bowel containing tumor with the exception that ligation of the inferior mesenteric artery is delayed until mobilization is complete. The rectum is separated from the base of the bladder, prostate, and seminal vesicles anteriorly, and together with the mesorectum it is shelled out from the

hollow of the sacrum. The middle hemorrhoidal vessels are sacrificed only if the rectal stump is to be very short, such as occurs in palliative resections of the rectosigmoid and upper rectum. Mobilization is complete when the rectum can be pulled well up into the wound and there is a generous margin of healthy tissue below the tumor. Attention is now directed to the blood vessel pattern of the sigmoid and descending colon, for on this depends the success of the operation. The blood supply of the sigmoid is in the form of a vascular loop which is much shorter than the loop of bowel itself. The vascular bundle at the base of the mesentery must be sectioned for two reasons. First, in order to permit removal of tissues possibly invaded by extension of the growth, and second, to allow unfolding and elongation of the sigmoid loop. The point of section of the inferior mesenteric artery is extremely important, for after dividing this vessel the vitality of the sigmoid depends on the vessels supplying the marginal artery. If the upper and lower sigmoid arteries arise separately the ideal site for section is between them, for then the blood will enter the upper sigmoid artery, pass into the marginal artery, and thence back into the lower sigmoid artery, and so on to the distal extremity of the loop. A problem presents itself when the sigmoid arteries arise from a common trunk, for if the inferior mesenteric artery is divided below the sigmoid trunk, it is often impossible to elongate the sigmoid loop, and if the artery is sectioned above the sigmoid trunk the left colic artery may be too slender to maintain an adequate blood supply through the marginal artery. However, the quandary is not too great because in any event one has to depend to a certain extent on what happens to the color of the bowel after ligation. If after division of the inferior mesenteric vessels there is any question about the viability of the bowel as evidenced by its dusky color, attempts at restoration of continuity must be abandoned. The choice then remains of continuing with anterior resection by closing the rectal stump and forming an abdominal artificial anus or by proceeding with the classical abdominoperineal resection.

The surgeon, having satisfied himself that the circulation in the sigmoid is unimpaired by section of the inferior mesenteric artery as evidenced by maintenance of its healthy pink color, cuts the mesorectum at as low a level as is consistent with the introduction of the anastomotic sutures and frees the anterior wall of the rectum from adherent fat tags. Low suturing of the rectum makes possible subsequent digital examination of the anastomotic site and reduces the amount of tissue dependent on the inferior hemorrhoidal vessels. The rectum is then double clamped and cut across with the actual cautery. The McClure modification of the Furniss clamp[9] is ideal for the rectal stump since the bowel can be controlled by the needle introduced through the clamp after the latter is removed. The sigmoid is likewise dealt with, being certain to leave enough bowel to allow for anastomosis without tension. The tumor, adjacent bowel, inferior mesenteric vessels, and portions of

both the mesosigmoid and mesorectum are thus removed to satisfy the requirements of a radical operation. If a Furniss clamp has been used to close the sigmoid colon it is now removed, the bowel controlled by the needle or pin, and a closed anastomosis is carried out. After the first row of interrupted silk sutures are put in, the needles are removed, the septum is broken down, and a second row of silk Lembert sutures is inserted. A rectal tube is now inserted through the anus up past the anastomosis to splint the bowel and carry off intestinal secretions. An open anastomosis is just as readily carried out and perhaps permits more accurate suturing. Five grams of sulfanilamide powder are dusted into the pelvis and the pelvic floor is re-formed about a Penrose drain. As the abdominal incision is being closed, an additional 5 Gm. of sulfanilamide are put in the various layers and a small rubber tube is used to drain the space of Retzius. The operation requires about the same time as the combined abdominoperineal resection. There is a good deal less shock.

AFTERCARE

The functioning colostomy allows early resumption of alimentary feeding and so hastens convalescence and healing. The pelvic drain and rectal tube are left in place for at least five days, so that the integrity of the anastomotic site may be investigated by injecting methylene blue into the distal loop of the colostomy. Some leakage usually occurs for the rectum, having no peritoneal covering, heals slowly. Crushing of the colostomy spur should be delayed until the anastomosis has healed and final closure of the colostomy is best deferred for at least a month. Patients become ambulatory in twelve to fourteen days and usually are able to leave the hospital in two and one-half weeks. The total hospitalization period is between four and five weeks.

COMPLICATIONS

Primary healing of the anastomotic site is the exception rather than the rule, owing to the lack of peritoneal covering of the rectal stump. Failure of the marginal artery to provide adequate blood supply to the end of the sigmoid must be a factor in some instances. Contrary to what might be expected, the blood supply of the remaining portions of the rectum is satisfactory even when the rectal stalks have been sacrificed. The inferior hemorrhoidal vessels alone apparently are capable of nourishing the lower rectum.

Delayed healing of the anastomosis, whether from actual loss of bowel tissue or failure of the sutures to hold, means that the union is effected by granulation tissue. Contraction of this scar tissue invariably results in narrowing of the anastomotic site, sometimes to the point of actual stricture. Repeated dilatation may keep the opening patent in some patients while in others the difficulty is so great that inguinal colostomy is necessary.

RESULTS

The foregoing opinions are based on a small personal experience of thirty-one operations performed during a three-year period, 1940 to 1942, inclusive. The series is necessarily limited because combined abdominoperineal resection is routinely performed for carcinoma of the rectum and anterior resection is reserved for the small group in which the indications for the operation appear to be clearly defined. There were two operative deaths, one on the fifth postoperative day from liver necrosis considered due to sulfonamide and the other on the eighteenth postoperative day from paralytic ileus. The mortality rate of 6.5 per cent compares favorably with that of the combined operation. Seven of the operations (22.3 per cent) were for tumors of the low sigmoid. There were eight patients (25.8 per cent) on whom the operation was only palliative because of liver metastases or local extension of the disease. One patient with liver metastases was able to work for one year before he finally succumbed. Stricture of the anastomotic site has occurred in three patients. One has required permanent colostomy, but the other two have been kept patent by repeated dilatations. Two patients have persistent fecal fistulas. Although insufficient time (six months to three years) has elapsed to discuss survival rates, the fate of the patients to date is approximately the same as for a similar group following the combined operation. Of the twenty-one patients who survived operation and whose operation might be classed as curative, two (9.5 per cent) have died and an additional two (9.5 per cent) show evidence of recurrence.

SUMMARY

1. The rationale and technique of the anterior approach for excision of carcinoma of the rectosigmoid and upper rectum are presented.

2. The use of the operation is suggested as an alternative not as a substitute, for combined abdominoperineal resection in selected cases.

3. The advantage and complications are discussed.

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PRIMARY RESECTION (CLOSED ANASTOMOSIS) OF THE COLON AND RECTOSIGMOID

Including Description of Abdomino-Anal Methods for Restoration of Continuity Accompanying Excision of Carcinoma of the Rectal Ampulla*

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PROCEDURES UNDER DISCUSSION

CURRENT practice in the University of Minnesota Surgical Clinic is to try to resect all unobstructed lesions of the colon in one stage, establishing intestinal continuity by oblique end-to-end closed (aseptic) anastomosis, without antecedent or complemental colostomy or decompressive vents, other than an indwelling tube. Lesions in the rectosigmoid, whose lower limits are within 10 to 13 cm. from the anal opening, as determined by proctoscopic examination, are treated similarly. In addition, for suitable carcinomas of the rectal ampulla between 5 and 10 cm. from the pectinate line, I am endeavoring to do a one-stage abdomino-anal proctectomy with preservation of the sphincters, establishing continuity by variants of methods described by others previously. The attainment of good to excellent continence, in the majority of the few patients who have been operated upon, suggests that a restudy of the Kraske and Hochenegg sacroperineal methods (or variants of them), with special attention to an abdomino-anal method of dissection and restoration of intestinal continuity with preservation of the sphincters, is in order. Furthermore, the emphasis which has been given to the *upward* spread of cancer of the rectum by the studies of Westhues (1930), Wood and Wilkie (1933), Gilchrist and David (1938), and Coller, Kay and MacIntyre (1940) suggests definitely that operations of this type are legitimate procedures, as long as one does not compromise on the extent of the removal, or invoke the procedure in instances in which proximal lymph node blockage may have permitted retrograde or downward migration of metastases. Obviously, in lesions in juxtaposition to the sphincters, and in ampullary lesions with local extension beyond the bowel wall, the orthodox abdominoperineal operation, in which a liberal portion of the levator ani muscle and the sphincter muscle are sacrificed, is to be preferred to the abdomino-anal operation described herein.

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The colonic resections reported herein have been done by five surgeons; the larger number, however, were done by two surgical residents and me. The rectosigmoid resections and the abdomino-anal operations for ampullary carcinoma were done by me.

THE RISE AND DECLINE OF THE EXTERIORIZATION OPERATION

The adoption of the exteriorization operation for carcinoma of the colon by Mikuliez (1903) was, in its time, a definite forward step in the surgical management of colonic cancer. Bryant (1882), Bloch (1892), and Paul (1895, 1912) had previously reported instances in which the exteriorization principle had permitted extirpation of colonic lesions at lesser risks. It was the advocacy of the procedure by Mikuliez and his report of a favorable experience with its use, in a large series of cases, that gave this method of dealing with colonic malignancy an important impetus. Prior thereto, the method in general use for lesions in both the right and left colon was primary resection employing the open anastomosis. In his initial report, Mikuliez (1903) reported a group of twenty-four cases, in which exteriorization, accompanied by immediate removal of the lesion in some of them, was done, followed by secondary closure of the colonic stoma with a mortality of 16.6 per cent. Mikuliez favored a one- or two-stage resection for lesions of the right half of the colon and reserved the exteriorization procedure for lesions of the left colon. Up until quite recently, the precepts of Mikuliez, with reference to choice of procedure in dealing with colonic malignancy, have been followed quite generally. Lahey (1932) extended the exteriorization plan to lesions of the right colon, a suggestion which has not met with wide adoption or favor.

It was the prevalent high mortality from peritonitis that persuaded the surgeons of a generation and more ago to abandon primary colonic resection in favor of the exteriorization principle. Surgery of that time was not ready for primary resection. Oblique section of the bowel, with re-establishment of intestinal continuity by the closed method of anastomosis, has changed all this. Surgeons, who have schooled themselves in the precepts of Halsted with reference to intestinal suture technique, find that a satisfactory one-stage, oblique, end-to-end anastomosis can be made anywhere in the intestinal canal.

Schoemaker (1921, 1927), Wilkie (1939), Campbell (1940), and Whipple (1940) have been ardent advocates of the one-stage closed anastomosis. Wilkie and Whipple favor an auxiliary cecostomy or other external drainage vent for lesions of the left colon. Campbell felt no necessity for establishment of an external safety vent. Schoemaker (1927) advised a preliminary cecostomy for obstructive lesions in the descending colon. In the cases herein reported, a complemental decompressive vent was employed only three times, all in resections of the pelvic colon. Appendicostomy was done twice and in the one pa-

tient in this series of resections in which an open anastomosis was made, a complemental colostomy was done. In one of the appendicostomies, infection of the wound occurred. Therewith, external decompressive vents, as an accompaniment of colectomy, were given up altogether. Cheever (1931) was able to report a series of thirty-five cases of primary resection in the colon for malignancy in which anastomoses were made by the open method with a mortality of only 8.5 per cent. Cheever felt the employment of an external decompressive vent important; when it was omitted, the mortality increased considerably (24 per cent). The routine employment of suction applied to an indwelling duodenal tube probably has rendered unnecessary the use of such external drainage vents. Stone and McLanahan (1942) report a mortality of 10.6 per cent employing the closed anastomosis in colonic resections, whereas when the open anastomosis was employed the mortality was 20.6 per cent.

An important advantage of primary closed resection over the exteriorization operation is in the amount of mesentery constituting the lymphatic drainage area which can be sacrificed. Rarely, if ever, need the surgeon compromise on the extent of excision of mesentery in primary resection; whereas, obviously, in the exteriorization operation, there are practical limits to the amount of mesentery that can be excised without risking the viability of the bowel brought through the abdominal wall.

THE OPERATION

The material embraced in this report covers a two-year period (April 1, 1941, to April 1, 1943) during which time sixty primary resections were done for carcinoma of the colon and rectosigmoid. The closed or aseptic method has been in use in this clinic for a longer period of time. Only within the period of the study, however, has the policy been followed consistently of attacking adherent growths by removing the tissue in juxtaposition to it. In other words, studied attempts have been made to avoid contamination during operative procedures occasioned by coming unexpectedly upon a perforated lesion. In instances, in which preliminary dissection disclosed probable perforation of the lesion against the abdominal wall, mesentery, ureter, uterus, or bladder, a part of that structure would be sacrificed rather than accept the risk of spillage and bacterial contamination. The hope lent that sulfonamides, such as sulfaguanidine and succinyl sulfathiazole, would sterilize the intestinal content of the colon and render spillage through contamination of perforated lesions innocuous has not been borne out in the experience of this clinic. The only reliable safeguard against the contingency of opening such perforated lesions is to adopt the arbitrary policy of sacrificing even such important structures as a ureter or an additional loop of bowel. This principle of operation envisages the performance of more radical procedures but with a greater economy of life. Economy of the surgeon's

time becomes a relatively unimportant consideration when weighing the element of hazard to the patient presented by two alternative schemes of procedure. Also, only during the two-year period under consideration have the surgeons in this clinic become familiar enough with the nutritional needs of the debilitated patient to eliminate largely the losses sustained on this score in earlier years. The item of preparing patients satisfactorily for operation, who have lost considerable weight, and the problem of meeting caloric and nitrogen requirements of such patients are matters of major importance in dealing with poor-risk patients who frequently require formidable operative procedures. Acute colonic obstructions are excluded from this study, save in so far as such patients came up for consideration of resection after relief of the obstruction. There were six patients in this group who had antecedent colostomy for acute obstruction.

MEETING CALORIC AND NITROGEN REQUIREMENTS

Patients, who have been supported by their own fat stores for fairly long periods and whose existence might be described as having been autocannibalistic, frequently, at operation, are found to have fatty livers. And patients with fatty livers tolerate strenuous operative procedures very poorly. A systematic and careful inquiry into the character of food ingestion and the extent of weight loss is, therefore, extraordinarily important. The greater the percentile loss in body weight, the longer must be the period of preoperative preparation. Weight losses in excess of 25 per cent of the initial body weight demand a long period of preoperative feeding of a high protein, high carbohydrate, low fat diet. Patients with acute obstruction, obviously, must have an antecedent decompressive operation. Patients with mild obstruction, who exhibit large weight losses and who require a long period of preoperative feeding, also should have an antecedent colostomy; occasionally, however, if the weight loss is not large, intravenous feeding of a 20 per cent glucose solution, amino acids, and plasma will suffice and make a temporary colostomy unnecessary in patients with mild obstructive symptoms. The precepts of Madden and Whipple (1940), Ravdin (1940), and their associates have guided us in meeting the caloric and nitrogen requirement of patients who have sustained large weight losses. My associate, R. L. Varco (1942), has compounded two diets which in our experience have met the requirements of preparing hospital patients, who have lost considerable weight, for operation. In gastric cases with obstruction, the problem is even more difficult in patients who have lost 30 to 35 per cent of their body weight, a minimum of three weeks usually has been employed in replacing depleted body stores with a high protein and carbohydrate and low fat diet. Successful gastric resection has been carried out latterly on two patients exhibiting recent weight losses, constituting 35 to 37 per cent, respectively, of the body weight.

IMPROVING THE OPERATIVE MORTALITY SCORE

Reduction of operative mortality is essentially the same problem as stopping the leaks in an expense account. No surgeon probably will learn to keep all the leaks sealed. However, it is very reassuring to note, as competence in a clinic improves in one item after another in the many problems involved in the care of surgical patients, how those increments of gain are reflected directly in an improved mortality. The best surgeons of the past generation were content with a mortality of 10 per cent in formidable operations for malignancy in the gastrointestinal canal. However, small gains in knowledge here and there, such as improved anesthesia, effectual schemes of preventing intestinal distention, and a better understanding of the importance and the technique of preparing patients for operation and caring for them after, should begin to be apparent. Avoidance of deaths, from pneumonia and peritonitis, attending operations of election is almost within the surgeon's grasp, if he will only be alert and responsive to the available means of thwarting these disasters, which have pursued the surgeon stealthily and too effectively since the very beginnings of abdominal surgery. Yet, when one contemplates the infirmities of age as well as the debility frequently attending gastrointestinal neoplasms, the goal of a low mortality appears difficult for consistent achievement. As the surgeon's confidence increases in methods of preparing poor-risk patients for operation, he is persuaded to accept risks of a strictly borderline character. With advantages of management unknown to our surgical predecessors of a generation ago, we should be able to improve upon their record of accomplishment and still extend the benefits of operation to a larger group of patients. A greater salvage of life is to be achieved obviously through urging patients with symptoms suggestive of a colonic malignancy to report for painstaking examinations at an early date. Yet, the surgeon's responsibility is to deal with the problem as he finds it. Perhaps in no malignant neoplasm in the body are determined efforts, directed at excising widely an adherent growth, more commendable than in the colon. As contrasted with the stomach, the number of long survivals or apparent cures attending the grubbing out of difficult adherent neoplasms in colonic malignancies is large, as the experience of many surgeons attests. Long periods of palliation attending resection, in the presence of hepatic metastases, in my experience are not unusual. Survival beyond six months, when gastric resection is carried out in the presence of hepatic metastases, appears to be distinctly unusual. Survival beyond one year, under similar circumstances when the primary lesion is colonic, is not unusual, in my experience.

I. COLON

Plan of Operation.—Preoperative preparation of the colon: We have tried most of the expedients which have been suggested for preparing

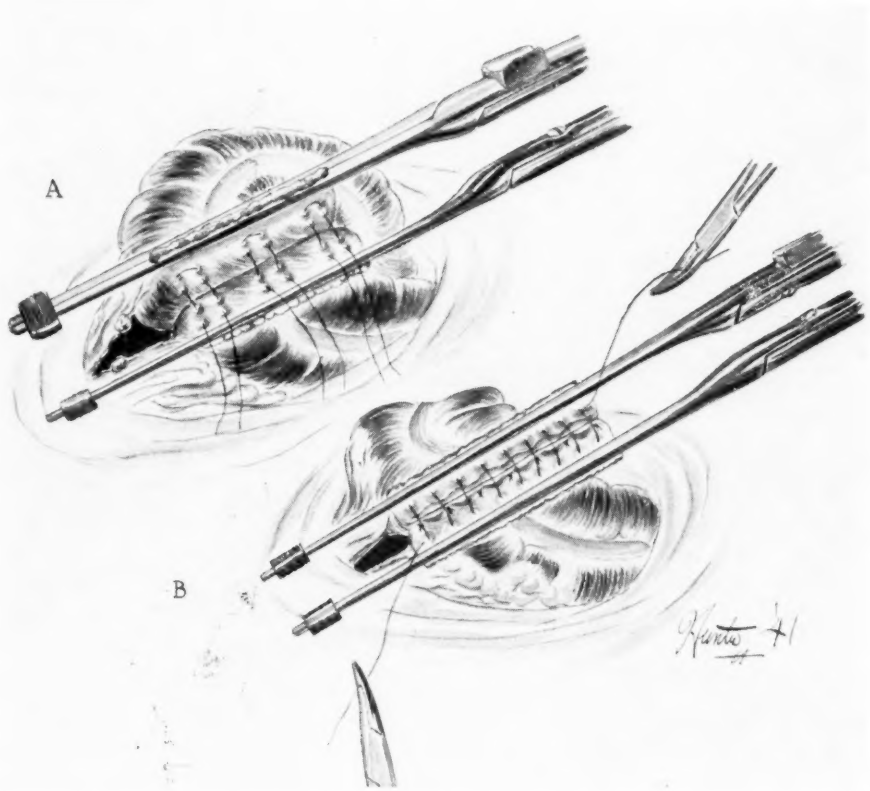
the colon for operation. None are wholly satisfactory. In this series of cases, there has been a fairly large number in which the preparation was poor—usually in patients with low-grade obstruction, frequently unrecognized preoperatively. Yet, employing a closed or aseptic mode of suture, the surgeon need not change his plan of operation because feces are present in the bowel. In several patients in this series, primary colonic resection was done despite the presence of feces proximal to a somewhat stenotic lesion. It is my impression that the preoperative administration of a liberal amount of mineral oil by mouth and the giving of colon flushes just prior to operation are the best schemes of insuring an empty colon. Sulfaguanidine and succinyl sulfathiazole have been employed and each has been given up in favor of the preoperative administration of enemas. No sulfonamide is given prior to operation.

Indwelling tube: Over a period of more than twelve years in this clinic, patients having abdominal operations of election have gone to the operating room with an indwelling duodenal tube in place. To this practice, patients with colonic or rectal malignancy are no exception. Suction is employed prior to, during, and after operation. After gastric resection, the duodenal tube is left in place three full days after operation; after partial colectomy, the tube is allowed to remain for five days. Whipple (1940) has come to put considerable reliance on the Miller-Abbott tube in colonic surgery. In this clinic, too, we have learned to appreciate many of the advantages of the Miller-Abbott tube; however, as a prophylaxis of intestinal distention, the ordinary nine-hole indwelling duodenal tube meets the situation admirably in most patients. Moreover, if the Miller-Abbott tube, placed well down in the reaches of the small intestine, is used as a prophylaxis against postoperative distention often it is found necessary to put an additional tube down through the patient's other nostril into his stomach, a circumstance which is trying to the patient, his relatives, and his surgeon.

Anesthesia: Cyclopropane has been the basal anesthetic agent for abdominal surgery in this clinic for years. During the past year, a combination of cyclopropane and spinal anesthesia has been employed. The anesthetist's technique of reducing the patient's respiratory movements to a minimum by artificial inflation of the lungs is a scheme particularly acceptable to the surgeon, for it insures a quiet abdomen. Improved anesthetic methods have been a great boon to the surgeon, permitting him to be more deliberate and painstaking in his operative procedures.

Incisions: The vertical incision has been used largely; in right hemicolectomies, however, an oblique incision beginning beneath the left costal margin and coursing downward and to the right above the umbilicus is employed frequently. It affords good exposure and gives ready access to the midtransverse colon, where the anastomosis will be made. This incision is not a physiologic one with respect to innervation and blood supply as is the Hoag incision which courses obliquely downward

in the other direction, paralleling nerve and blood supply. The oblique incision herein described, however, is superior to the Hoag incision in affording exposure where it is needed most, a consideration which outweighs any other. Surgeons have come to have far more trust in the transverse or the oblique, as contrasted with the vertical incision, in that evisceration with the latter is more likely to occur. Unfortunately, for low lesions in the left colon, only the vertical incision affords optimal exposure, and good exposure is so important that it becomes a dominant consideration.



A and *B*.

Fig. 1.—Aseptic (closed) oblique end-to-end anastomosis after excision of pelvic colon. *A*, Placement of posterior row of sutures. Three or four Halsted mattress sutures of fine silk (Deknatel C, two-pound test) are placed with a fine curved-eye needle (Anchor series 1833-1). Then similar, additional, interrupted sutures are placed between. This, the outer row of sutures, should not lie more than 7.5 mm., away from the clamp. If only 5 mm. of the bowel wall are employed in the suture, the resultant lumen will be larger.

B, The inner posterior row is made with a running suture of 000 catgut. The ferrules are knocked off the clamps before they are rotated for placement of the anterior row of sutures.

C, The double ferrule has been placed over the tips of both blades and the locking device fastened over the mid-portion. A running suture of catgut is placed near the clamps anteriorly. It is to be noted that straight mosquito forceps are employed to identify the posterior catgut sutures, while curved mosquito clamps are used for the same purpose anteriorly.

D, The clamps have been withdrawn; the anterior and posterior catgut sutures at each end have been tied together, and placement of a row of interrupted Halsted mattress sutures completes the anastomosis. No portion of the mesentery is employed to secure closure at the mesenteric border. (Resection clamp available through V. C. Mueller Co., Chicago). (From Wangensteen: Intestinal Obstructions, courtesy of Charles C Thomas, Publisher).

The anastomosis: An end-to-end oblique closed (aseptic) anastomosis has been employed to the exclusion of all other methods of anastomosis in this clinic, save in subtotal colectomy in which an anastomosis is effected between the terminal end of the pelvic colon and the side of the cecum. For multiple lesions of the colon, leaving the cecum and the ascending colon free, I have become very partial to this scheme of anastomosis (Fig. 1). For idiopathic dilatation of the colon, so-called Hirschsprung's disease, it is, I believe, a quite satisfactory operative procedure.

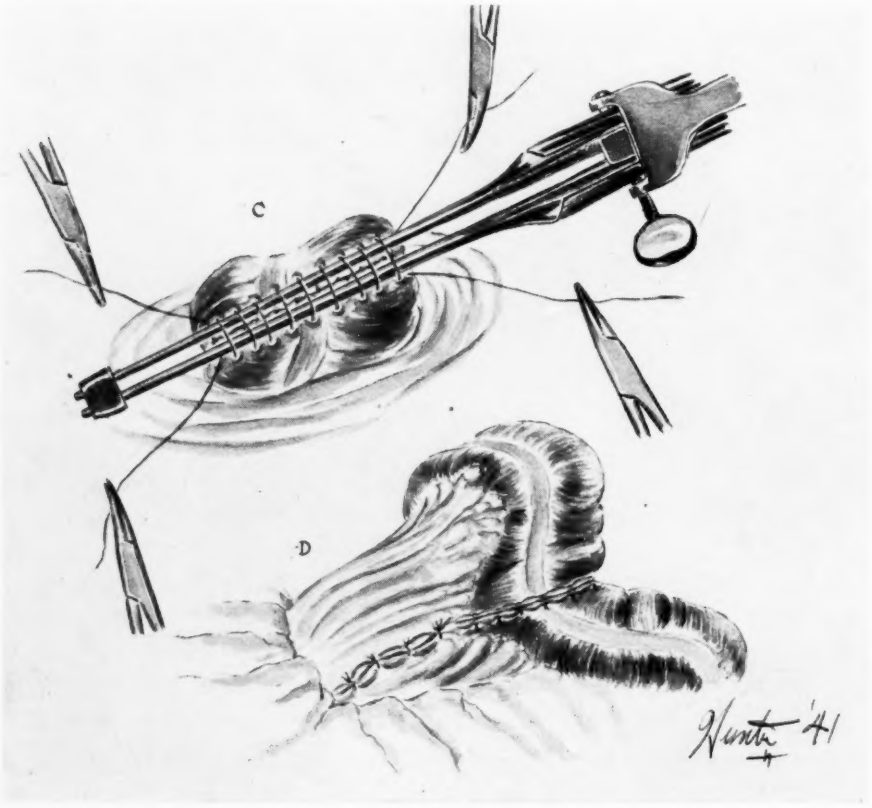


Fig. 1, *C* and *D*.—For legend see page 409.)

The Italian surgeon Parlavecchio (1898, 1900), the innovator of the closed method of making intestinal anastomoses, noted the importance of making an oblique section of the bowel, leaving the mesenteric edge longer. On consulting the original writings of Parlavecchio during the past year, I was struck with the great similarity between the clamps employed by Parlavecchio and those made for me in 1938 by Mr. John A. Phelan of the Scientific Apparatus Shop on the University campus. Parlavecchio described the use of an instrument with well-tempered, flexible, and thin blades with biting grooves. Parlavecchio employed a locking device over the shank of the handles not unlike that in my in-

strument. The only things missing in the older instrument are the single and double ferrules which prevent spread or separation of the thin blades of the clamp as it is closed on the bowel. Interestingly enough, Parlavecchio incorporated in his anastomosis clamp a refinement which Mr, Phelan and I discussed but decided to omit, viz., a curve in the handles to permit easier rotation of the instrument for the anterior suture, after completion of the two posterior rows of suture. Experience has shown that the straight-handled clamp, which is easier to manipulate, meets the requirements of the situation very satisfactorily.

The mesenteric angle in end-to-end anastomoses and the problem of the inturn: The problem of the mesenteric angle in oblique end-to-end anastomoses throughout the intestinal canal undoubtedly has occasioned many surgeons to adopt the less physiologic procedure of side-to-side anastomosis. I have solved this problem for myself in the manner illustrated in Fig. 2. The mesentery is not to be relied upon to close

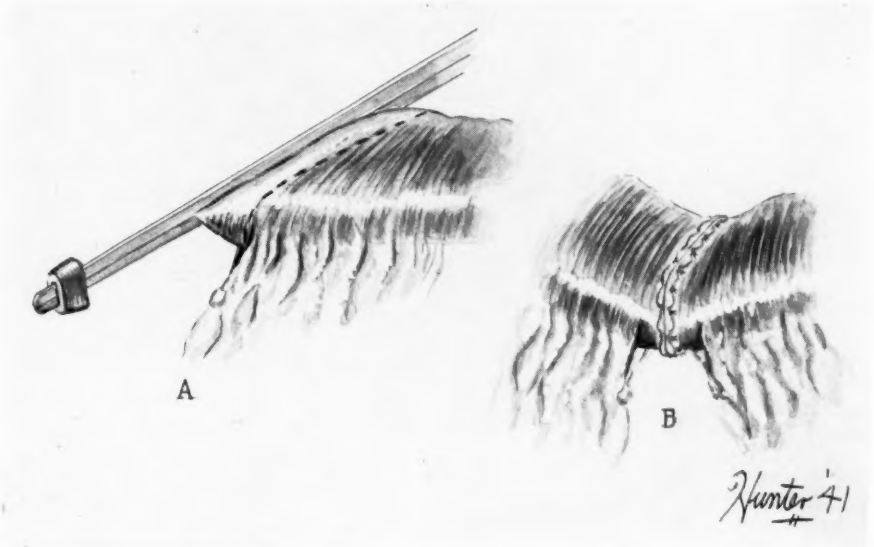


Fig. 2.—Solution of the difficulty of the mesenteric angle. *A*, Placement of the clamp upon the bowel wall at an acute angle (about 45 degrees). The external row of sutures will come within the confines of the dotted line, that is, the first posterior row and the last anterior row will not be more than .75 cm. (preferably .5 cm.) away from the clamp.

B, Detachment of the mesentery to a point .75 cm. beyond the site of application of the clamp in an oblique end-to-end anastomosis permits placement of every suture in the bowel wall. The mesentery is not employed in the anastomosis. The manner of dealing with mesenteric angle, shown here, concerns the small intestine; the same technique is employed in resections of the colon. The preparation of the colon for the anastomosis is a little more difficult. (From Wangensteen: Intestinal Obstructions, courtesy of Charles C Thomas, Publisher.)

the mesenteric border of the bowel; nor should the mesenteric border present any special problem if the scheme is followed of denuding the bowel of its mesentery 7.5 mm. beyond the site selected for section of the bowel. Furthermore, every stitch is to be placed in the gut wall. Two rows of sutures, in which the extent of the inverted bowel does not exceed 7.5 mm., constitute a satisfactory inturn. No matter where

in the intestinal canal the anastomosis is made, the surgeon should set himself the task of employing only 5 to 7.5 mm. of the adjacent walls of the tubular viscera to be approximated.

The epiploic appendages: Despite the apparent importance of the epiploic appendages in the blood supply of the colon, in the interests of placing each and every stitch in the bowel wall, I have sacrificed these appendages as indicated in Fig. 3. Grasping a fatty epiploic appendage, overlying the bowel wall in a suture, is not an acceptable substitute for careful placement of the stitches into the submucous coat of the bowel.

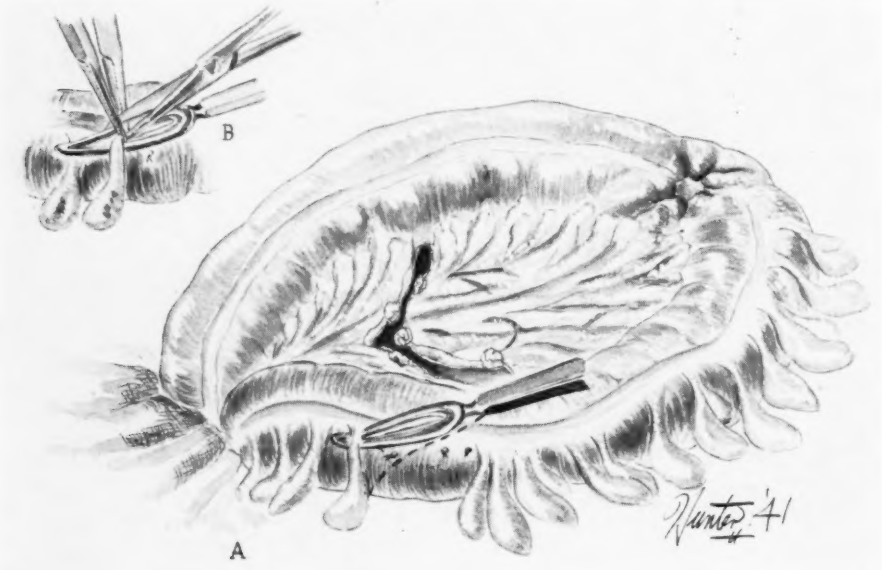


Fig. 3.—Mode of preparing the colon at operation for an oblique end-to-end anastomosis. *A*, The dotted line indicates the proposed site for application of the clamp.

B, The fatty tags are underrun with a dissector. Each fatty tag is divided and tied as indicated, to obviate hematoma formation. The bowel wall is to be cleared for a distance of ¾ cm. beyond the proposed site of section. This maneuver permits the surgeon to place each suture directly in the bowel wall. (From Wangensteen: Intestinal Obstructions, courtesy of Charles C Thomas, Publisher.)

Antecedent or complemental colostomy unnecessary: If each and every stitch grasps the submucous coat of the bowel, the sutures are otherwise well placed, and the blood supply of the anastomosed segments is preserved, there does not appear to be any necessity for a preliminary colostomy or little if any justification for the so-called "defunctioning colostomy" of Devine (1938). A well-made anastomosis will not leak. Only in the presence of obstruction is an antecedent decompressive vent necessary. For acute obstructions of the pelvic colon with great distention, it has long been the practice of this clinic to establish a transverse colostomy, a procedure which can be accomplished with little hazard.

Implantation of sulfathiazole: On completion of the anastomosis, a small amount of sulfathiazole is implanted about the anastomosis. In-

asmuch as most anastomoses in colonic resections remain in contact with the small intestine, it is undesirable to leave a large quantity of sulfathiazole in the peritoneal cavity because of the known adhesive stimulating quality of the drug. When the anastomosis can be extraperitonealized completely, as in resections of the rectosigmoid, a larger implantation of sulfathiazole can be made with no misgivings on the score of adhesion formation. Our usual plan is to implant not more than a total of 3 Gm. in the ordinary adult patient, the larger fraction being implanted in the abdominal wall. No sulfonamide is given prior to operation; no additional sulfonamide is given after operation, until after the elapse of forty-eight hours, when a total of 1 to 2 Gm. of sulfadiazine is given subcutaneously in divided doses for two or three days if an indwelling urethral catheter still remains in place.

Intraperitoneal vaccination: We have never employed preoperative intraperitoneal schemes of vaccination in this clinic. On theoretical grounds alone the plan does not appear to have real merit. Why subject the patient to this ordeal? It would appear that the neoplasm and operation are tribulations enough for the patient. Why provoke fever and make the patient ill unnecessarily just prior to the trials of operation?

Division of Cases.—The location of the lesions appears in the tables. The majority of the operations were undertaken for carcinoma (see Table I). In the cecal group of resections, there were four instances

TABLE I

NATURE OF LESIONS

	NUMBER OF CASES	HOSPITAL DEATHS	MORTALITY (PER CENT)
Carcinoma	46	1	2.1
Regional ileitis and colitis	4	0	
Ulcerative colitis	2	0	
Diverticulitis	4*	0	
Hirschsprung's disease	3	0	
Tuberculosis	1	0	
Multiple intestinal fistulas	1	0	
Total	61	1	1.6

*One patient also had regional ileitis (see text).

of regional ileitis or ileocecitis, necessitating removal of the terminal segments of the ileum and the right half of the colon. Among the 18 patients with lesions in the pelvic colon, one had tuberculosis, and 4 had diverticulitis. One of these also had a regional enteritis involving the terminal ileum and cecum, necessitating a simultaneous ileocolic resection and a resection of the pelvic colon. The patient was dismissed from the hospital ten days later with the wound healed. The patient with tuberculosis of the pelvic colon also had two simultaneous colon resections, one in the right half of the colon and the other in the pelvic colon. As indicated in the footnote to Table II, of the 7 patients for whom a

one-stage subtotal colectomy was done, 6 had noncancerous lesions. Of the 60 patients for whom colonic resection was done, 15 had lesions other than malignancy. There were no deaths in this group.

TABLE II

LOCATION OF LESIONS

	NUMBER OF CASES	HOSPITAL DEATHS
Cecum	14	0
Ascending colon	4	1
Hepatic flexure	3	
Descending colon	5	0
Pelvic colon (exclusive of rectosigmoid)	18	0
Multiple lesions necessitating subtotal colectomy (1 stage) anastomosing terminal ileum or cecum to terminal pelvic colon*	7*	0
Rectosigmoid	10	0
Total	61	1 (1.6% mortality)

*This group includes one patient with polyposis and multiple carcinomas, one patient with diffuse diverticulitis and diverticulosis, two patients with ulcerative colitis, three patients with Hirschsprung's disease. In three of the seven, an end-to-side anastomosis was made as shown in Fig. 4; in the other four, the terminal ileum was anastomosed to the colon pelvinum end-to-end.

Mortality and Resectability.—The total hospital mortality for resections of the colon and rectosigmoid during this two-year period was 1.6 per cent. Of the 61 operations, a closed primary anastomosis was done in 57 patients (Table III). In 60 of the 61 patients, excision of the lesion was effected by one method or another.

Among the 61 patients, 46 had malignant lesions in the colon; 45 were carcinoma. There was one lymphosarcoma of the cecum. Of the 46 patients with colonic malignancy, 42 had a primary closed resection. Entero-anastomosis alone was done in 1 patient, a two-stage resection in 1, an open anastomosis in 1, and a three-stage exteriorization was done once (Table III). A primary resection of some type was done in 43 of the 46 patients with malignancy (93.4 per cent). In all but 1 of the 46 patients, however, removal of the growth actually was accomplished (97.8 per cent). This is probably a higher resection rate than can be justified by more experience. Five of these patients had hepatic metastases; in 2 of them the hepatic metastases were extensive, but the lesions in the colon were stenotic enough to necessitate either resection or its only alternative, colostomy. Simultaneous cholecystectomy or appendectomy has been done several times as an incident to primary colonic resection. Coincidental total hysterectomy was performed once because of intimate adherence to a rectosigmoidal lesion. Removal of a portion of parietal peritoneum overlying an adherent lesion is not an unusual circumstance and must be done if entry into a perforated lesion is to be avoided. Partial excision of the urinary bladder was undertaken twice. The right kidney was removed twice for adherent, perforated lesions of the ascending colon and hepatic flexure.

In one of these patients, Mr. F. G., aged 49 years (Univ. Hosp. No. 709574), it became necessary also to remove a strip of the inferior vena cava in addition to the kidney and ureter and finally, to my great embarrassment, to remove a section of the retroperitoneal duodenum. In the appraisal of the operability of the lesion, it was believed that a resection of the anterior face of the duodenum would suffice. The presence of an unrecognized duodenocolic fistula made it mandatory to sacrifice a fairly long segment of the duodenum ligating the pancreatic ducts. I was not certain whether the ampullary termination of the common bile duct was removed with the duodenum; consequently, I estab-

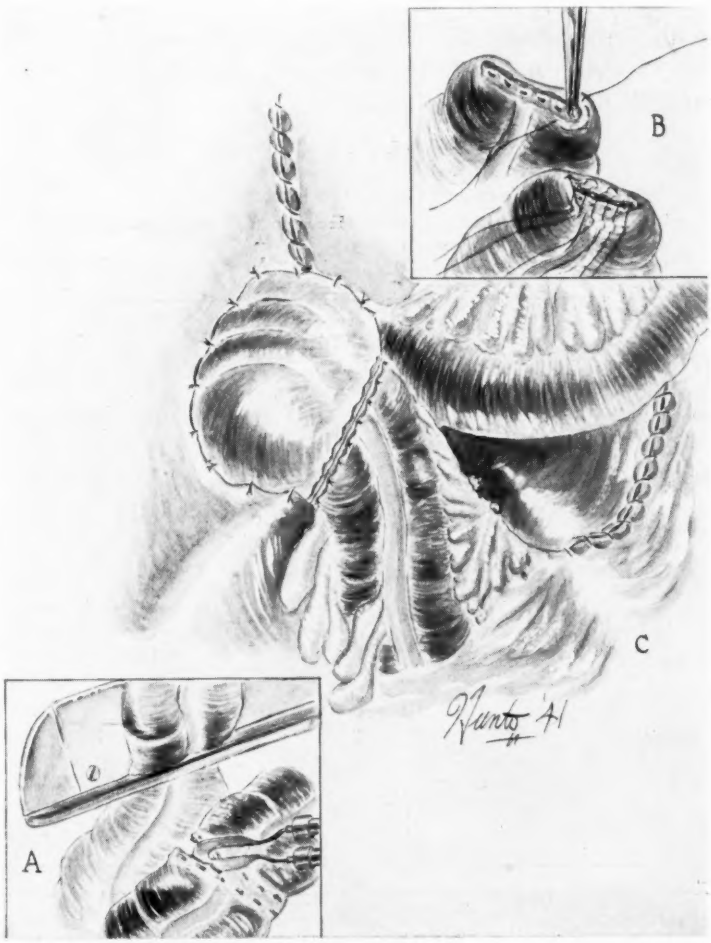


Fig. 4.—Subtotal colectomy for multiple lesions in the colon, with end-to-side anastomosis between pelvic colon and side of cecum. This type of operation as a single stage procedure has been done for multiple carcinomas (pelvic colon and hepatic flexure), and for polyposis and chronic ulcerative colitis without involvement of the rectum or cecum.

A, Use of v. Petz suturing apparatus in the division of the ascending colon.

B, Inversion of the divided colon with interrupted Halsted mattress suture.

C, The completed oblique end-to-side anastomosis between side of cecum and end of pelvic colon. Closure of the mesenteric defects is accomplished with surprising ease, after subtotal colectomy. (From Wangensteen: Intestinal Obstructions, courtesy of Charles C Thomas, Publisher.)

lished external tube drainage of the gall bladder. Later, when the duodenal specimen was studied carefully by the pathologist, it was observed that the ampulla of the common bile duct was on the specimen. This patient died from massive hemorrhage from an actively bleeding artery in the wall of the antrum of the stomach sixteen days after operation. In other words, a Mann-Williamson operation had been done on the patient. At autopsy, both intestinal anastomoses were intact. Transplantation of the bile duct into the stomach or duodenum might have averted this disaster. In his monograph on *The Surgery of Pancreatic Tumors,* Brunschwig (1942) gives no indication that this complication has been observed in the Whipple operation for carcinoma of the ampulla or carcinoma of the head of the pancreas. It would appear, therefore, that return of bile to the intestinal canal is mandatory when the pancreatic ducts are to be ligated.

TABLE III

TYPES OF OPERATIVE PROCEDURES

	NO. OF CASES	HOSPITAL DEATHS	TALITY MOR- (%)	RESEARCHES
Exploratory only	0	0	0	
Colostomy only	0	0	0	
Enteroanastomosis only	1	0	0	Perforated lesion with abscess and metastases
Two-stage resection (preliminary enteroanastomosis)	1	0	0	Perforated lesion with abscess
Exteriorization (3 stages)	1	0	0	Severe cirrhosis
Open anastomosis	1	0	0	Closed anastomosis in ileum and open anastomosis between rectum and pelvic colon with resection of bladder for multiple intestinal fistulas (Dennis), also complemental colostomy
Primary resection	57	1	1.7	Antecedent transverse colostomy for acute obstruction 6; complemental appendicostomy 2; complemental colostomy 1
Total	61	1	1.6	

Postoperative Hospital Stay.—Complications: The mean postoperative hospital stay following resection for the 60 of the 61 patients who recovered from operation was 12 days; the average length of hospital stay was 14.3 days. Within 14 days of operation, 36 patients were dismissed. More patients were dismissed on the eleventh postoperative day than on any other, viz., 15 patients. Ten patients were dismissed on the twelfth postoperative day; the largest number dismissed on any other

one postoperative hospital day was 4 dismissals on the tenth, fifteenth, and seventeenth postoperative days. Three patients were dismissed on each of the following postoperative days: the thirteenth, fourteenth, fifteenth, and eighteenth. The other dismissals were dispersed over a wide interval. The longest postoperative stay was 35 days, occasioned by a postoperative adhesive obstruction which remained refractory to suction

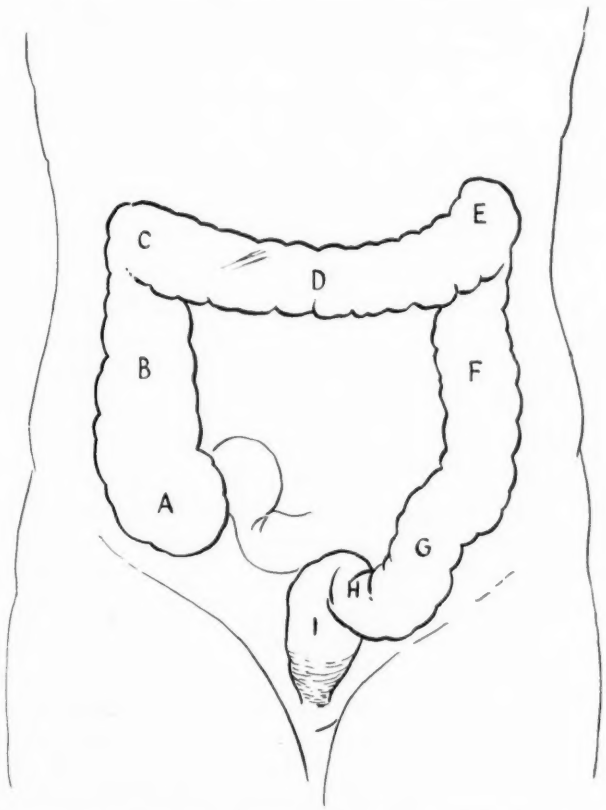


Fig. 5.—Location of lesions with reference to type of resection. *A*, Cecum. Right hemicolectomy with removal of terminal segments of ileum, and lymphatic drainage area, re-establishing continuity by oblique end-to-end anastomosis between ileum and transverse colon. No more ileum should be removed than necessary lest persistent diarrhea be provoked by simultaneous sacrifice of right colon and water-absorbing segments of the ileum.

B, Ascending colon. Same operation as for *A*.

C, Hepatic flexure. Same operation as for *A*. If mesenteric lymph node involvement is not great, and right colic artery and vein can be preserved to the cecum, and end-to-end anastomosis can be effected between ascending and transverse colon; in the main, the operation described under *A* is preferable.

D, Transverse colon. For a small lesion the avascular suspension ligaments of the hepatic and splenic flexures may be divided, permitting end-to-end union between the proximal and distal ends of the transverse colon. For large lesions in which the tension factor persists after mobilization, the ascending colon may be anastomosed to the distal end of the transverse colon; or the type of operation shown in Fig. 4 may be employed.

E, Splenic flexure. Usually end-to-end anastomosis between the pelvic and the transverse colon constitutes the best choice of procedure.

F, Descending colon. For small lesions, local segmental resection; more frequently the type of operation described under *E* becomes necessary.

G, Pelvic colon. Local segmental resection. The flexure of the colon makes this procedure almost uniformly feasible.

H, Rectosigmoid. Segmental resection with end-to-end anastomosis between pelvic colon and rectum. See Fig. 6.

I, Ampulla of rectum. For lesions less than 10 and more than 5 cm., from the pectinate line, ampullary resection may be done in suitable cases.

and the use of the Miller-Abbott tube, secondary operation being necessary for the relief of the obstruction. In the main, the chief causes for lengthening of the postoperative hospital stay beyond the conventional 11 or 12 days were the infirmities of age and the debilitated status of a poorly nourished patient. The one patient for whom the exteriorization operation was done had a total postoperative hospital stay of 33 days—13 days following the initial exteriorization and excision, 10 days after cutting the spur, and again 10 days following closure of the colostomy. The one-stage closed aseptic anastomosis is the operative procedure of choice from the standpoint of the patient's economy of time and hospital expense. A convalescence without complication assures prompt wound healing, minimal mortality, and early recovery.

The Occurrence of Diarrhea After Right Hemicolectomy.—Transient diarrhea after excision of the right colon together with 2 or 3 feet of the terminal ileum has not been an unusual circumstance. Perhaps this is as it should be, for water absorption is largely a function of the ileum; in addition, a further drying process of the intestinal content takes place normally in the right half of the colon. Whenever sacrifice of this segment of the colon is accompanied by loss of 2 or 3 feet of the terminal ileum, as becomes necessary to remove adequately the lymphatic drainage area for a cecal carcinoma, temporary diarrhea may follow. I have never observed diarrhea following sacrifice of a good portion of the left colon; nor have I seen it in the cases of subtotal colectomy in which the cecum is anastomosed to the colon pelvinum or rectum. As a matter of fact, there are 2 patients in the present group for whom right hemicolectomy with sacrifice of a short segment of the ileum was done more than a year ago, who continue to have, without other apparent cause, four to five stools a day—a diarrhea which has remained refractory to all the usual measures of dealing with such situations.

II. PRIMARY CLOSED RESECTION FOR LESIONS AT THE RECTOSIGMOIDAL JUNCTURE

As early as 1910, Balfour had reported excising lesions in the pelvic colon as a one-stage procedure, establishing intestinal continuity over a rubber tube. In 1920, Balfour made a second report upon the utility of this procedure. In 1908, Lockhart-Mummery described excision of a lesion in the pelvic colon through a perineal incision, making the anastomosis over a glass tube. In the main, however, it appears that most surgeons have settled upon a one-stage abdominoperineal operation as the only operative procedure which meets satisfactorily the problem presented by lesions of the lower pelvic colon or upper rectum. There have been only a few dissenting voices. Horsley (1937), Dixon (1939, 1940), and Dunphy (1940) have each reaffirmed their belief in the thesis that lesions in the rectosigmoid can be excised in accordance with the

principles of good cancer surgery with restitution of intestinal continuity. To Dixon, in particular, great credit is due for indicating that this procedure can be accomplished with a reasonable risk. Dixon performed the operation usually in three stages, performing first colostomy, then excising the lesion, establishing continuity by an open anastomosis. The final procedure was closure of the colostomy. Arnold (1939) and Arnold and Shea (1940) have employed an abdominosacral three-stage procedure for carcinoma at the rectosigmoid, an operation not unlike the sacral exteriorization of Küttner (1910).

My interest in trying to restore continuity by primary resection for lesions in the terminal pelvic colon and at the rectosigmoidal juncture was provoked by a patient for whom a colostomy had been established elsewhere for an ulcerative lesion in the pelvic colon. This patient was determined to have intestinal continuity restored. He had twice previously been subjected to exploration, at his own persistent insistence, in vain attempts to accomplish restoration of continuity. No vestige of a colon had been found in the peritoneal cavity beneath the level of an inguinal colostomy when Dr. Charles E. Rea of this clinic performed the last exploration. Proctoscopic examination disclosed a rectum patulous to the proctoscope to 12 cm. It was my intention to dissect beneath the pelvic peritoneum for the blind rectal pouch, to remove the colostomy, and to establish continuity by end-to-end suture between the rectum and the pelvic colon. The colon was so full of impacted fecal material, from cecum to the colostomy outlet, that an anastomosis with the colon did not appear feasible. The contracted colostomy outlet apparently precluded ready evacuation of the colonic content despite preoperative administration of enemas. Recourse was had, therefore, to the expedient described by Stone (1927), in which a loop of ileum was interposed, an end-to-end anastomosis being effected between the rectal ampulla resurrected from the sacral concavity and the ileum. Because of the extraordinary fecal impaction of the entire colon, the proximal end of the ileum was led out to the exterior. During convalescence, the colostomy opening was enlarged and vigorous catharsis readily remedied the disquieting colonic impaction noted at operation. At a subsequent procedure, end-to-end union was effected between the transverse colon and the ileum, the colostomy and the intervening colon being excised.

As an aside, it may be interesting to record the character of the fluid drained out through the temporary ileal fistula. This was the first time in this clinic that an anastomosis had been made at so low a level. At that time (June 9, 1941), the operation seemed technically very difficult. Apparently a few sutures engaged the opposite bowel wall, causing a temporary obstruction, an occurrence which permitted us to collect daily from the 20 cm. ileal segment, through a catheter in its proximal end, an opalescent, white, somewhat milky fluid. The fluid looked not unlike a rich admixture of mucus with fluid from anywhere in the

intestinal canal. The surprising thing, however, was the odor of this innocent-looking fluid. Quite uniformly a startled look lighted the faces of all who sampled the aroma of the bottle. It was a pungent, unpleasant odor, which permeated the patient's room. Presumably, this is the normal ileal secretion. No such odor was perceptible on the patient's breath at this time, initially on admission to hospital, or after complete restoration of intestinal continuity.

This patient, Mr. R. P., aged 46 years (Univ. Hosp. No. 667947), has been very pleased with the re-establishment of intestinal continuity, and the operation of the new channel apparently has duplicated normal colonic behavior in every way.

This procedure suggested the feasibility of excising carcinomatous lesions at the rectosigmoidal juncture, with primary re-establishment of intestinal continuity. During the period covered by this study, primary resection has been done for rectosigmoidal lesion in a group of ten cases (Table II). The same technique of establishing intestinal continuity is employed as has been found practical in aseptic or closed resections of the stomach and the small intestine or colon. The clamps employed are the same. The only difference in the technique is depicted in Fig. 6. The broad attachment of the mesentery to the rectum obviates the necessity of making an oblique section of the rectum, as is mandatory in primary anastomoses in the colon. In consequence, a transverse section on the lower rectal segment can be made with salvage of rectal wall for the anastomosis, an item which makes the operation easier. Apparently, the middle and lower hemorrhoidal arteries are quite adequate to support a normal blood flow to the residual rectum, for in each such operation, obviously, it becomes necessary to sacrifice the superior hemorrhoidal artery.

Antecedent colostomy, save in the presence of acute obstruction, appears to be unnecessary; similarly, a complemental external decompressive vent appears unnecessary. As in the colonic anastomoses, each and every suture is placed in the gut wall, great care being observed to secure satisfactory approximation with an inturn, not exceeding 7.5 mm. Moreover, it is surprisingly easy to extraperitonealize the entire anastomosis.* It is also a simple procedure to push a rectal tube beyond the anastomosis after completion of the suture. I employ a No. 22 tube and have an assistant push it up from below, threading the tube about 10 cm. above the anastomosis. Every third day the tube is withdrawn 2 to 3 cm. to preclude tension effects of the tip of the tube upon the pelvic colon. No intestinal fistulas occurred in the group. Four of the ten patients in the series were dismissed from the hospital with a healed wound in eleven days and two on the twelfth postoperative day. One patient remained twenty-four days; the others left the hospital on the seventeenth postoperative day, with healed wounds.

*In primary resections of the rectosigmoid, the surgeon has no justification in being too proud to have recourse to this effective therapeutic expedient of affording his patient added protection.

Arbitrary Surgical Definition of the Lower Proctoscopic Limits of Lesions of the Rectosigmoid.—The rectum begins where the colon ceases to have a mesentery. Prior to the BNA reclassification of the constituent parts of the pelvic colon and rectum, the colon pelvinum was counted

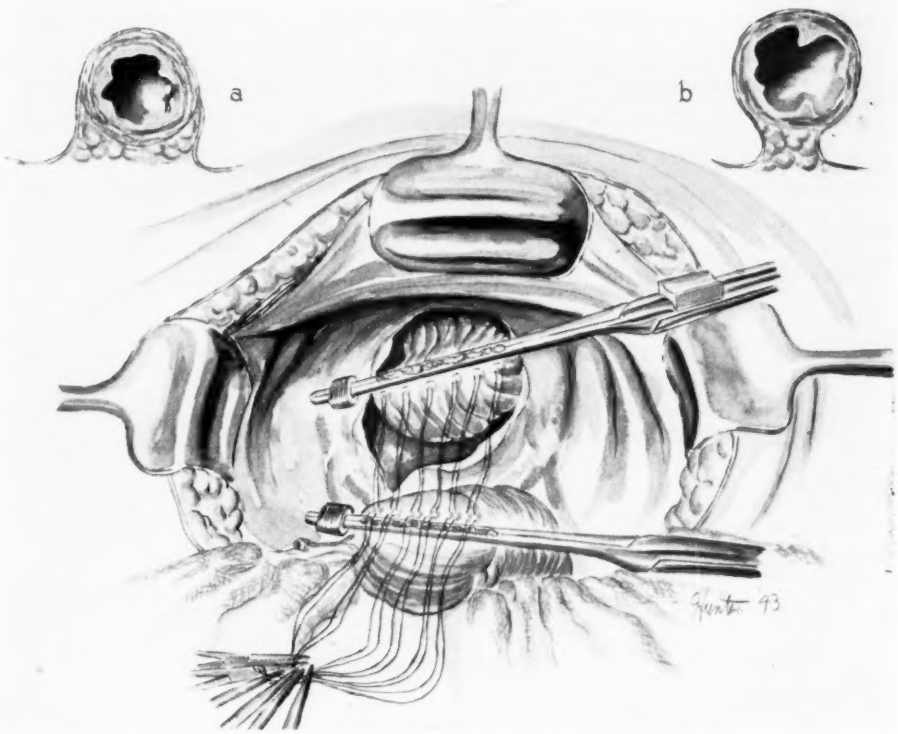


Fig. 6.—The type of anastomosis is essentially that shown in Fig. 1. However, because of the depth at which the anastomosis must be made in the pelvis, the scheme illustrated here facilitates the procedure. In the ordinary anastomosis a 13 to 16 inch (32 to 40 cm.) silk suture is employed. Here a 20 inch (50 cm.) suture is used. All the sutures are placed and the segments to be approximated, the rectum and pelvic colon, are allowed to remain at some distance from one another until the last suture is placed. Then the anastomosis is completed as is indicated in *B*, *C*, and *D* of Fig. 1.
The width of the usual mesenteric attachment of the colon pelvinum and rectum is shown in *A* (3 to 9 o'clock); the usual nature of the mesenteric attachment is shown in *B* (5 to 7 o'clock). The broader mesentery of the rectum makes it feasible to place the clamp on the lower segment, in rectosigmoidal anastomoses, directly transverse to the long axis of the bowel—an enormous advantage in a low difficult anastomosis. The only consideration which prompts an oblique placement of the clamp on the rectal segment is the matter of gaining added width for a broader lumen.

as a portion of the rectum (Fig. 7). In designating lesions of the rectosigmoid, I have employed rather arbitrary distinctions, including only those lesions whose lower extent, as observed through the proctoscope, is not less than 10 nor more than 13 cm. from the pectinate line. The rectum is not straight as its name would imply; it has a deep anteroposterior curve and lesser lateral curves. Lesions, whose lower proctoscopic limit is more than 13 cm. from the anal opening, in the main, can be resected easily without mobilizing the rectum. Even for lesions within the arbitrary limits described, there is some variation, in the ease or difficulty with which the operation is done, depending on the depth of the

peritoneal cul-de-sac, and the adiposity of the patient. In lean patients with a deep peritoneal cul-de-sac and a large pelvis, resection for lesions at the rectosigmoid juncture may be easy and necessitate little mobilization of the rectum as contrasted with the adipose patient, especially if the peritoneal cul-de-sac is not deep. Interestingly enough, when patients who have had resections at this level are submitted to proctoscopy after operation, the suture line often is described as being at about the same distance from the anal opening as was the lower extent of the lesion initially, despite the excision of 2 to 3 cm., of normal appearing bowel below the lesion. Obviously, this seeming paradox can be explained only by the surgeon's mobilization of the rectum at operation.*

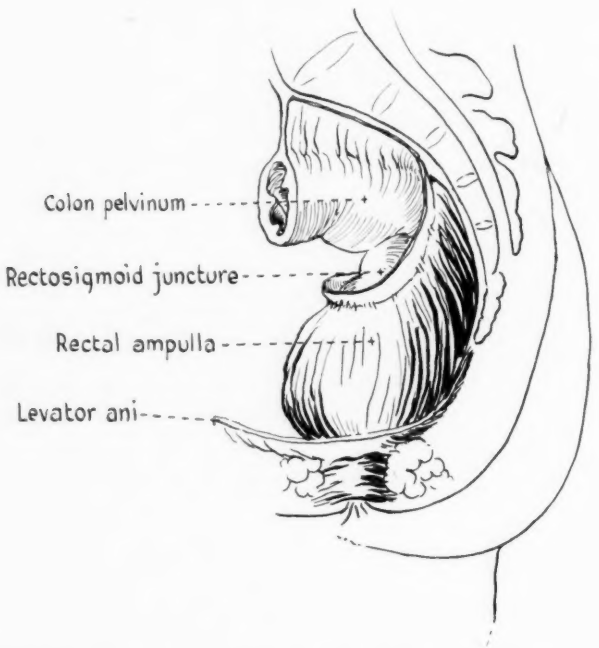


Fig. 7.—The rectum and colon pelvinum. The latter, once recognized as a part of the rectum, now is accepted generally as constituting a part of the pelvic colon. (Redrawn from Corning's Anatomy.)

It is unlikely that the resection rate will be as high for rectosigmoidal lesions as in the colon proper. I have not hesitated to perform partial colectomy in both the right and left colon in the presence of rather extensive hepatic metastases. In a similar circumstance, the lesion being at the rectosigmoidal juncture, the surgeon readily could justify to himself performance of the easier alternative operation of colostomy.

Concomitant Presence of Rectal Polyps With Lesion in Pelvic Colon or Rectosigmoid Contraindicates Resection.—It is perhaps not out of

*My colleague, Dr. William C. Bernstein, of the Division of Proctology, kindly checked the inferior limits of all lesions within the range of the proctoscope before operation and the site of the suture line after operation. This information is very helpful to the surgeon and affords him an opportunity of becoming better oriented in the anatomicosurgical aspects of the problem.

place to sound a note of warning over enthusiasm for primary resection with restoration of intestinal continuity in a patient presenting a carcinoma on the basis of a polyp, exhibiting at the same time polyps in the rectum which appear benign on proctoscopic examination. Recently in this clinic, a patient from the present series, Mr. W. D., aged 60 years (Univ. Hosp. No. 619643), was submitted to abdominoperineal excision approximately 16 months after segmental resection had been done in the pelvic colon. It was believed that the polyps in the rectum could be kept in check by fulguration. Despite repeated fulguration carcinoma developed. In another patient, Mrs. M. L., aged 49 years (Univ. Hosp. No. 648542), two lesions were observed proctoscopically, one was a carcinoma at 12 cm. from the anal opening, the other was described as a benign polyp at a distance of 10 cm. from the anus. Microscopic study of the resected segment showed that the polyp was malignant, even though there was yet no demonstrable invasion of the circular muscle. To trust to fulguration for control of rectal polyps, when a similar polyp at the rectosigmoidal juncture or in the pelvic colon already has become malignant, does not appear to be a wise course.

Preservation of normal sexual function: That impotence is a frequent accompaniment of the abdominoperineal operation of removal of the pelvic colon and rectum is the common experience of surgeons. Jones (1942) indicates that the incidence of impotence following the operation in male patients is approximately 95 per cent. In rectosigmoidal resection, with immediate restoration of intestinal continuity, this unfortunate side effect of the abdominoperineal operation is avoided.

III. ABDOMINO-ANAL METHODS FOR EXCISION OF CARCINOMA OF THE RECTAL AMPULLA WITH RESTORATION OF CONTINUITY AND PRESERVATION OF THE RECTAL SPHINCTERS

The Kraske and Hochenegg methods of perineal or sacral resection of the rectum with preservation of the rectal sphincters are well known. Kraske (1885) described excision of a segment of the sacrum with resection of the rectum only, restoring continuity by circular suture. Hochenegg (1888) described two methods, known respectively as the "pull-through" and the "invagination" methods. The former has enjoyed the widest use in the hands of Hochenegg and his pupils as well as by others. The Küttner (1910) plan of sacral exteriorization already has been alluded to in the section on primary resection for rectosigmoidal lesions.

A rather general and increasing enthusiasm for the abdominoperineal method of operation for carcinoma of the rectum, together with pathologic studies, which suggests definitely a centripetal spread of lymphogenous metastases from rectal cancer, sometimes at a rather great distance from the local lesion—these factors have led to a general abandonment of the perineal or sacral methods of excision of cancer of the rec-

tum, save on special indication. Even though the one-stage abdominoperineal operation appears to be a more formidable operation than colostomy followed by posterior excision, in practiced hands, the hazards of these procedures in standard-risk patients should be approximately the same. The gain in more complete excision of the lymph drainage area in the abdominoperineal operation definitely suggests it to be the better procedure.

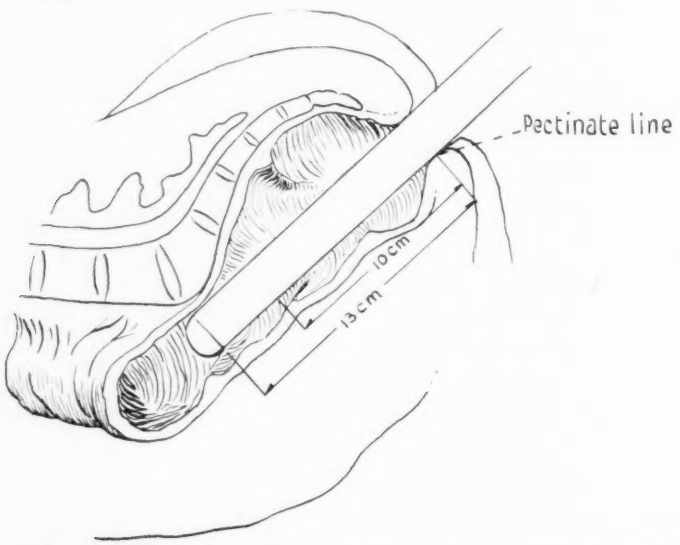


Fig. 8.—Arbitrary surgical definition of the region involved in rectosigmoidal resection. Ordinarily lesions seen through the proctoscope at more than 13 cm. above the pectinate line can be resected with far greater ease than lesions shown within the limits designated here. Lesions at less than 10 cm. from the anus may be dealt with by methods described under ampullary resection.

Limitations of Resection Methods.—In addition to the shortcomings of the perineal or sacral methods of amputation of the rectum just described, when the rectum is resected by either of these routes with preservation of the sphincters, the incidence of fistula formation is high, no matter whether the methods of Hochenegg or Kraske are employed (see Fig. 11). A perusal of the papers of Körbl (1913) and Goldschmied (1914) and other pertinent literature suggests that the incidence of primary wound healing is not high by any of these methods. Rotter (1912) has devised a pedicled skin-flap procedure to deal with the item of fistula formation, following the Kraske circular suture method of rectal resection. Furthermore, even with preservation of the sphincters, the recovery of complete continence by either method has not been too promising. Mandl (1940), a pupil of Hochenegg and an ardent advocate of the pull-through method of Hochenegg, states that satisfactory ultimate continence is obtained in 50 per cent of instances by the Kraske circular suture method, and in 60 to 65 per cent by the Hochenegg method. Körbl (1913) of the Eiselsberg Clinic stated that primary healing occurred in only 20 per cent (total of 27 cases) with

employment of the Hochenegg "pull-through" method; recovery of complete continence was observed in 36 per cent. Employing the Kraske suture method, Körbl states that primary healing occurred in 39 per cent (total of 34 cases) and eventual complete continence occurred in 66 per cent. Wilensky (1942) recently reported preservation of the sphincters in the abdominoperineal operation, a suggestion made several years ago by Kraske (1905) and practiced by Perthes (1927). Pannett (1943) records employing the same method.

The Abdomino-Anal Scheme of Operation Employing the Pull-Through or Suture Methods.—My own thought on the matter was to combine the advantages of the abdominal removal of the lymphatic

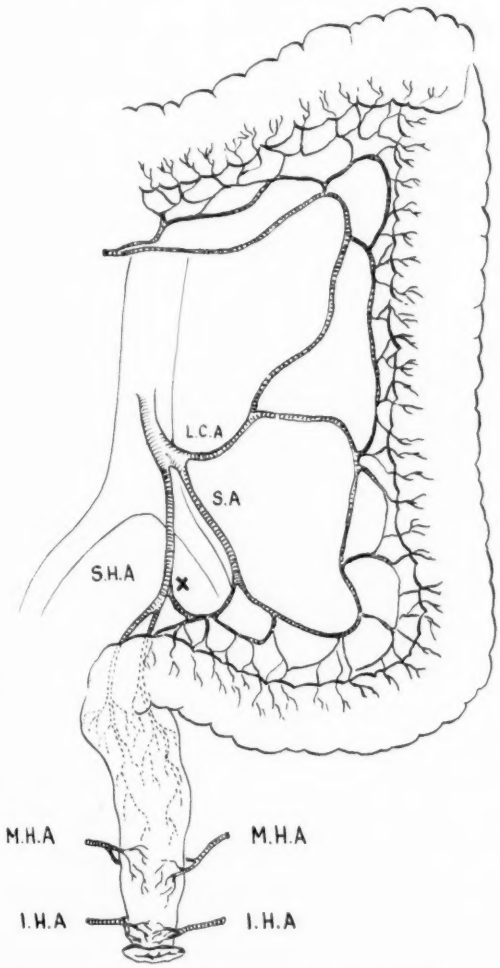


Fig. 9.—The blood supply of the left colon. In segmental resections of the pelvic colon and for lesions at the rectosigmoid, Sudeck's critical point has no particular import. In such anastomoses, the residual portion of the rectum is nourished through the middle and inferior hemorrhoidal arteries (*M.H.A.* and *I.H.A.*). The superior hemorrhoidal artery (*S.H.A.*) is to be ligated above the point designated "X" (Sudeck's critical point). A high ligation and division of the superior hemorrhoidal artery permits mobilization of the colon and blood may reach the most distal end of the pelvic colon through the left colic (*L.C.A.*) and the sigmoid (*S.A.*) arteries.

drainage area, and eliminate the troublesome problem of perineal fistula by either (1) pulling the pelvic colon through the anal opening or (2) by suturing the pelvic colon to the rectal wall, at the lower level of resection.

A recent search of the literature discloses that these methods too have had their advocates. As long ago as 1892, Maunsell, a surgeon in New

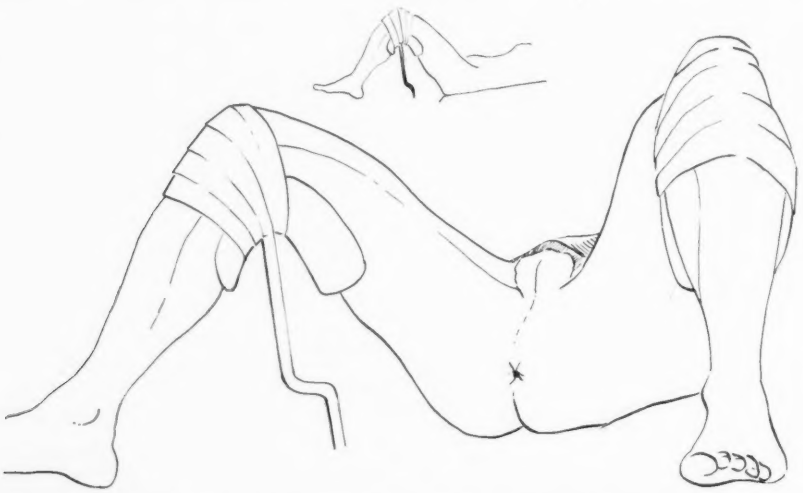


Fig. 10.—Position of the patient on the operating table; this position permits performance of the abdomino-anal operation of rectal resection for ampullary lesions without change of position. The elevated position of the knees handicaps the surgeon a little. It is possible that employment of sterile "pants" and adjustable stirrups with reference to height of elevation may facilitate the abdominal dissection.

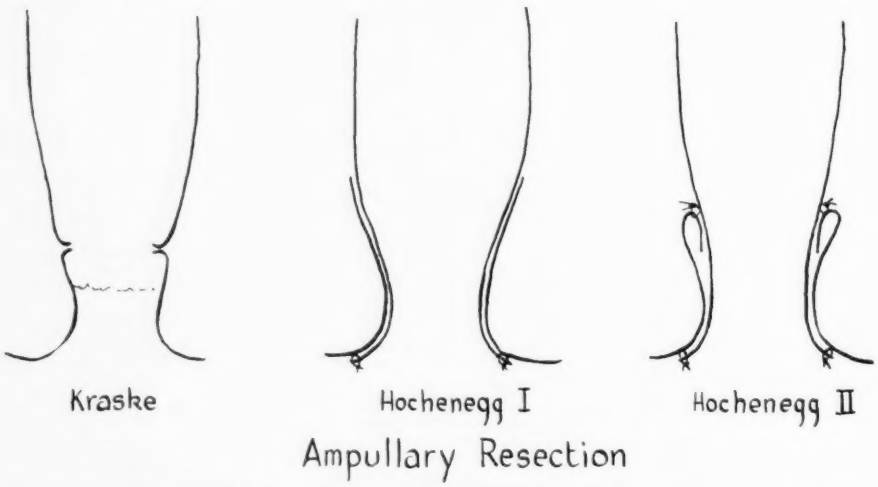


Fig. 11.—The ampullary resection methods of Kraske (1885) and Hochenegg (1888). These were carried out as sacroperineal one-stage resections. In the Kraske method, a circular suture was made. The Hochenegg I is the "pull-through" method, the procedure which has been used most widely. In the Hochenegg II method, the distal rectal wall is invaginated somewhat and the bowel is "pulled through" with placement of sutures.

One of the important shortcomings of all these operations lay in the complication of a perineal fistula. The same general methods of procedure have been carried out with the abdomino-anal methods described herein, omitting the sacroperineal dissection.

Zealand, described a method very similar to that employed by me. Maunsell intended his operation for lesions of the rectal ampulla and lower pelvic colon. Through an abdominal incision, he divided the rectum below the lesion and pulled the upper segment with tumor attached through the lower rectal segment after excision of the lesion; anastomosis was effected between the segments. He remarked that "a tailor always pulls a sleeve inside out to sew it." In 1901, Weir described an almost identical procedure, with this difference, that the rectal segment containing the neoplasm was removed through the abdominal incision before the pelvic colon was pulled through the lower rectal segment. As in Maunsell's method, the anastomosis was described as being effected in the "cold outside." Weir reported 3 cases in which this type of operation was performed for carcinoma located in each instance at 4, 3½, and 2½ inches from the anus. Bergeret and Livory (1940) describe an abdomino-anal procedure for lesions of the rectosigmoid, employing the principle of the Hochenegg invagination scheme on the lower rectal segment.

The Experience of This Clinic With the Abdomino-Anal Method.— During the past year, seven abdomino-anal operations for carcinoma of the rectal ampulla have been done in this clinic.* There have been essentially two plans of operation. In both, the patient is placed on the operating table as shown in Fig. 8. Whereas, this position handicaps the surgeon a little in the abdominal dissection, it possesses this advantage, that the patient's position need not be changed for the final stages of the operation. My first plan was to dilate the rectal sphincter and to dissect up the normal rectal mucosa, just above the pectinate line, much in the manner of the Whitehead operation for hemorrhoids. This short mobilized tube of mucosa is then closed by suture and a gauze pack impregnated with 2 Gm. of sulfanilamide is left in the supra-anal muscular cylinder. Following a change of gown and gloves, excision of the carcinoma of the rectum is completed by the usual abdominal method. The preliminary Whitehead maneuver from below facilitates the abdominal dissection. Whereas, in primary resection for carcinoma of the rectosigmoid, Sudeck's (1907) critical point apparently has no great significance for the surgeon (Fig. 8) in this procedure, on the contrary, in which the pelvic colon is to be pulled down to or through the anal canal, the maintenance of viability to the very tip of the pelvic colon becomes a problem of real concern to the surgeon. Four patients have been operated upon by the abdomino-anal pull-through method. One of these, Mr. N. F., aged 45 years (Univ. Hosp. No. 723502), a large muscular man, died of pyelonephritis and oliguria 12 days after operation. The day following operation, the patient's external sphincter was di-

*It is a pleasant task to acknowledge here the enthusiastic help and encouragement I have received from my associate, Dr. Richard L. Varco, in carrying out the latter type of operative procedure.

vided posteriorly because of gangrene of the segment protruding through the external sphincter.

The remaining three patients having the abdomino-anal procedure were operated upon in the following manner: in one, the preliminary Whitehead dissection was carried out, but following the abdominal dissection, excision of the neoplasm and mobilization of the pelvic colon, the operation was completed by suturing the pelvic colon to the remnants of the rectal wall just above the pectinate line. In the other two, the preliminary Whitehead maneuver was omitted, the removal of the carcinoma being effected from within the abdomen. In one of these, the operation was completed by the abdomino-anal pull-through maneuver; in the other, my associate, Clarence Dennis, sutured the pelvic colon to the lower level of rectal resection through a large Fansler proctoscope, while I completed the operation from within the abdomen.

I did a one-stage proctectomy and colectomy, pulling the ileum through the anal canal, for a patient of 16 years, Mr. C. E. (Univ. Hosp. No. 684951), with chronic ulcerative colitis involving the rectum. It was necessary to elongate the ileocolic artery, much in the manner with which one deals with the inferior mesenteric artery in the abdomino-anal pull-through maneuver for carcinoma of the rectal ampulla. The procedure was not a complete technical success, and a few weeks later the boy was readmitted, at which time ileostomy was performed. A well-functioning ileostomy or colostomy, obviously, is preferable to a perineal anus in which the sphincteric function is poor. Babcock (1932) is one of the few American surgeons who recommends a sacral anus to his patients in preference to a colostomy. I have had the privilege of talking with surgeons who have had personal experience with an abdominal colostomy and count it no great handicap in the ordinary activities of life.

Dissatisfaction With These Methods.—Primary healing did not occur in a single instance. It may prove that a preliminary colostomy should be done in these procedures to divert the fecal stream during the healing phase. Nevertheless, the ultimate recovery of something approximating normal continence in the majority of the patients operated upon suggests that efforts directed at preserving the rectal sphincters have some merit. I have been somewhat reluctant to perform complemental diversion of the fecal stream by colostomy, feeling that the continued maintenance of the normal channel for evacuation of the stool serves as a good prophylaxis against stricture formation. I have the impression that the suture method is superior to the pull-through maneuver; further, preservation of the entire thickness of the rectal wall in the lower segment is desirable. In other words, whereas, the preliminary Whitehead maneuver facilitates the abdominal dissection, this step in the procedure should be eliminated in the interest of preserving the lower rectal segment intact. In the Whitehead dissection, the submucosa apparently

is removed with the mucosa; there is also real hazard of inflicting injury upon the internal sphincter muscle.

All these factors suggest that the abdomino-anal suture method is the most effective way of dealing with carcinoma of the rectal ampulla, if one is to attempt preservation of the sphincters. The experience of this clinic with these methods has not been extensive enough to warrant any conclusions. These preliminary skirmishes with the problem are recorded here only to suggest that these initial trials indicate that a satisfactory technique of dealing with certain cases of ampullary carcinoma with full restoration of sphincteric function probably can be worked out.

Importance of internal sphincter: Whereas, this experience has been inadequate to enable formulation of the best plan of procedure in the preservation of normal continence, it has demonstrated to me the great importance of the internal sphincter in the maintenance of perfect control of gas and feces. One thinks ordinarily of the external sphincter as a strong muscle. It is, however, a voluntary muscle and subject to the fatigue of ordinary voluntary muscle. The internal sphincter, on the contrary, is a less dense sheet of muscle fibers, but being an involuntary muscle, it is not subject to the action of the will, nor does it exhibit the fatigue of voluntary muscle. A patient having had the Whitehead dissection, probably with trauma to the internal sphincter as a preliminary to one of the abdomino-anal operations described above, may find, when he attempts to walk from his bed to the toilet, early in convalescence, that his external sphincter tires, permitting the escape of gas or feces. This circumstance was particularly noticeable in the boy with ulcerative colitis, in whom the ileum was pulled through the external sphincter following proctectomy and colectomy.

Hospital stay: Two patients in this group left the hospital at 17 and 18 days after operation respectively. The average hospital stay for the 6 patients who survived operation was 26.3 days. Furthermore, whereas the patients with colonic and rectosigmoidal resections left the hospital with wounds healed and, usually, with complete restoration of normal intestinal function, the patients in whom the abdomino-anal resection was done for ampullary carcinoma had to endure a long healing period of several weeks beyond the long hospital stay. Nevertheless, it has been very reassuring to note the enthusiasm of these patients with reference to the item of salvage of the rectal sphincters and preservation of normal function. Further, it would appear that these patients also retain a normal sexual function as contrasted with patients having the usual abdominoperineal operation for carcinoma of the rectal ampulla.

SUMMARY

The experience of this clinic suggests that primary resection, employing the closed anastomosis, can be made with relative safety for car-

cinoma and other lesions anywhere in the colon as well as for rectosigmoidal carcinoma. Antecedent colostomy is necessary only in the presence of obstruction; complemental external decompressive vents are unnecessary. Among 60 resections performed for lesions of the colon and rectosigmoid juncture over a two-year period, there was one death, a mortality of 1.6 per cent. A high resection rate is compatible with a low mortality in colonic resections. A short hospital stay and healing period attend primary resection for lesions in the colon and rectosigmoid quite regularly. A convalescence without complication assures a low operative mortality and permits early dismissal from the hospital.

In addition, a preliminary report is made of the experience of this clinic with abdomino-anal methods of dealing with carcinoma of the rectal ampulla, preserving the rectal sphincters. Whereas, the healing period has been long in these patients, the ultimate return of function, approaching the normal, suggests that efforts directed at preserving the rectal sphincters are worth while.

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Editorial

Cancer of the Colon

ALTHOUGH great advances have been made in the treatment of disease generally, there are probably few conditions in which more has been accomplished regarding an increase in the operability and decrease in the mortality and morbidity than in lesions of the colon. This marked improvement is due to many factors, and no one technique can be credited with the results obtained today as contrasted with those obtained a decade ago, although one is likely to believe that the improvement in results which he has had is due to a particular form of therapy. Unquestionably, any one of the many factors which have been employed generally in the past decade would have resulted in an increase in the operability and a decrease in the mortality, but the combination of all of these factors is probably responsible for the results which are obtained at the present time.

Until relatively recently little attention was paid to a patient's preoperative nutrition. The importance of the maintenance of the protein balance was not appreciated until the detrimental effect of hypoproteinemia on the healing of wounds was demonstrated. Also, little was known about the essential role played by vitamin C in the healing of wounds. In ulcerative lesions of the colon as elsewhere, a vitamin C deficiency is likely to be present and unless corrected preoperatively and postoperatively, interference with the deposition of collagen results. The disregard of the frequently present hypoproteinemia and vitamin C deficiency in patients with colonic lesions was undoubtedly responsible for the relatively high incidence of leakage of the anastomotic site with resulting peritonitis which so frequently ended fatally following resection and anastomosis of the bowel. Adequate preparation of the patient generally and the preparation of the bowel locally has done a great deal to decrease the mortality rate in bowel surgery. Whereas those less familiar with the results obtained in bowel surgery are likely to credit the introduction of the sulfonamides with the improvement which has been obtained, it is undoubtedly the consensus of those with considerable experience in treating these cases that, although sulfonamides have been of value in decreasing morbidity and mortality, they are responsible for a relatively small part of the improvement of results. One cannot deny the beneficial effects of sulfonamides, and one should not decry their use. On the other hand, the results as reported by Wangensteen, who does not use sulfonamides either before

or after operation, only implanting a small amount of sulfathiazole about the anastomosis, it is obvious that good results can be obtained without the use of the "sulfa cure-alls." Also, it must be stressed, as repeatedly emphasized by Allen, that "although we believe that the proper use of sulfa drugs will prove helpful in dealing with colon surgery, we cannot overemphasize the caution that is to be looked upon only as an aid and is not to permit the slightest breakdown in the proven surgical principles heretofore established." Never will the use of sulfonamides supplant clean surgery.

Unquestionably, the use of aseptic methods of anastomosis has done much to improve the results and to decrease the morbidity. With the decreased incidence of contamination, the incidence of localized and generalized peritonitis becomes obviously lessened. These procedures alone undoubtedly have made possible the discontinuation of stage operations in many clinics. An aseptic anastomosis is technically more difficult to perform than open anastomosis and will be used more frequently by the more experienced surgeons than by the occasional operators. Probably this is another reason why better results are obtained with this type of anastomosis than with the open anastomosis, because, as has been emphasized by Allen, the segregation of these cases in clinics where techniques can be developed to handle them properly from every angle will undoubtedly result in a decrease in mortality and morbidity. Therefore, credit which has been given the aseptic anastomoses for lowering the mortality rate is probably due in part to the other measures which are used in these cases and not due entirely to absence of contamination.

The controversy concerning the use of one-stage and multiple-stage procedures still exists. One cannot be dogmatic in conclusions concerning which type of procedure should be used in a given case. Unquestionably, by improving the patient's condition preoperatively and by the use of aseptic anastomosis, it is possible to perform safely one-stage procedures which were not feasible before. The obvious advantage of the one-stage procedure is that the patient is subjected to a single procedure, and the convalescence is greatly shortened. On the other hand, one cannot help but be convinced by the experience at the Massachusetts General Hospital, where all of the previously mentioned measures are employed and where surgery is at its best, that there are many cases in which two-stage procedures are indicated and desirable. Obviously, in a given institution, as emphasized by Jones, the procedure to be used should be that which has been found most satisfactory in that particular clinic, but in the hands of the novice or occasional operator, unquestionably multiple-stage procedures are safer and will give better results than a single-stage procedure.

The increasing interest in more conservative procedures in the treatment of low sigmoidal lesions is of importance. The fact that these procedures are justified is based upon the investigations of David and

Coller and their associates, in which it was shown that although glandular metastases from rectosigmoidal carcinomas are extensive, they are generally in the upward direction. This permits the use of resection of the low-lying sigmoidal lesion with the re-establishment of the continuity of the bowel and the presentation of the normal sphincteric apparatus. It is in this type of procedure that a proximal defunctionating colostomy or a carefully performed aseptic anastomosis is imperative. It will be of interest to observe these cases for longer periods of time to see if there is any evidence of recurrence in the distal segment. The investigations of Coller and David suggest that these will not occur.

Although defunctionating colostomies are being done less frequently and undoubtedly with considerable justification in the larger clinics in which considerable experience has been gained, undoubtedly in the hands of men doing an occasional colonic resection they are valuable procedures. A large adherent mass in the sigmoid which appears inoperable becomes movable and much smaller following the production of a defunctionating colostomy as described by Devine. In such an instance, wide resection of the colonic mass together with the adjacent adherent parietes, with an end-to-end anastomosis, permits a cure which would otherwise be impossible. Even though resection has been so extensive that tension of the anastomotic line might result, one need not fear the results because if an insufficiency of the suture line occurs, the re-establishment of the continuity of the bowel by crushing the spur at the colostomy can be delayed until the suture has healed completely. This may take weeks or months, but the delay is of no importance aside from the fact that the patient has the inconvenience of a colostomy.

In a consideration of surgery of the colon, one must not forget the valuable procedure of obstructive resection, originally suggested by Rankin. In many lesions this is undoubtedly the best procedure available in that it eliminates adequately the malignant process and does so in a safe and efficient manner. Convalescence is not prolonged, and the end results are good.

Undoubtedly the use of the Miller-Abbott tube has done a great deal to obviate the necessity of a proximal enterostomy or colostomy. Certainly it is undesirable in a given case for tension to be applied to a recently anastomotic suture line, particularly if there has been any history of obstruction before. It is imperative, obviously, to relieve the obstruction in some way, either by preliminary use of the Miller-Abbott tube or a preliminary decompressive procedure on the bowel. With few exceptions, patients prefer the former procedure. On the other hand, there are some patients who cannot tolerate prolonged use of the tube which is necessary during the early postoperative period.

—Alton Ochsner, M.D.

New Orleans, La.

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

DESCENT OF THE TESTIS: ANATOMICAL AND HORMONAL CONSIDERATIONS*

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DESCENT of the testis into the scrotum occurs either during the prenatal period or near the time of puberty. Although the general aspects of the process are well known, the forces of descent have not been adequately explained.

Numerous developmental factors have been suggested. Several of these, discussed by Eberth (1904), are the following: (1) pressure upon the testicle by such developing viscera as the liver and the intestine, (2) shortening of the gubernaculum by contraction of its smooth muscle and by retrogressive shrinkage, (3) contraction of skeletal muscle of the inguinal cone, (4) accumulation of meconium in the large bowel (see Fig. 7), (5) caudal shifting of the gubernaculum due to changes in the developing bony pelvis, and (6) upward growth of the body over the testis.

Two hormonal factors have been proposed. One involves prenatal action of chorionic gonadotropin (Engle, 1932b). The other concerns scrotal stimulation by estrogen during pregnancy (Wislocki, 1933).

The purpose of this communication is to consider the main features of testicular descent and to interpret them in the light of recent observations.

ANATOMICAL CONSIDERATIONS

1. *Early Development of the Testis.*—The testis develops from mesothelium (celomic epithelium) which is situated medial to the mesonephros. The primordium of the testis, a thickening of the mesothelium, is apparent for the first time in 5- to 7-mm. embryos (Willier, 1939). Soon, thereafter, it loses its basal membrane and contributes cells to the gonadal blastema (Gruenwald, 1942). This subepithelial layer is apparently identical with the so-called "epithelial nucleus" derived by Felix (1912) from previously existing mesenchyme. Following studies on lower vertebrates, it was said that the primordial germ cells originate in the wall of the yolk sac (Fuss, 1912) and that they invade the

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developing gonad by migrating cranially along the dorsal mesentery (Politzer, 1928). But this method of formation has been denied by Stieve (1927), who maintains that the germ cells are derived exclusively from the mesothelium.*

Primary sex cords are formed either by invagination of the mesothelium (Simkins, 1928) or by differentiation from the gonadal blastema (Gruenwald, 1942).

Upon observing the gonads of young embryos, males may be identified by the presence of the developing tunica albuginea. By the 20-mm. stage (seven weeks), the primary sex cords begin to become separated from the overlying mesothelium due to the formation of a tunica albuginea. Separation is complete in 25-mm. embryos. Surprisingly, and rather frequently, secondary sex cords may be observed between the mesothelium and the tunica albuginea (Gruenwald, 1934, 1942); in this respect, the development of the testis simulates slightly that of the ovary. Possibly this formation of secondary sex cords is related to the occurrence of ovotestes in some cases of hermaphroditism.

Seminiferous tubules develop from the solid primary sex cords and acquire inconspicuous lumina (pseudolumina) in 90- to 358-mm. fetuses (Wilson, 1926).

The interstitial cells of the testis have been identified in a 43-mm. embryo (Kitahara, 1923). Apparently they develop "from the original gonad blastema either by way of gonadic cords or from the mesenchymal stroma of the organ" (Gruenwald, 1942). Stieve (1927) reports that they arise from mesenchyme.

Rete cords, considered originally to have developed from the epithelium of mesonephric corpuscles (Winiwarter, 1910), have, more recently, been derived from undifferentiated cells of mesothelial origin (Wilson, 1926; Gruenwald, 1942). These primordia of the rete testis have been recognized in a 15.2-mm. embryo. By the 90-mm. stage, the cords exhibit small lumina.

Developmental union of the seminiferous tubules with the vasa efferentia, according to Wilson, is accomplished before birth, in some cases as early as the fourth prenatal month.

2. *Prenatal Positions of the Testis.*—The maximum extent of the germinal ridge, the primordium of the testis (and ovary), is from the sixth thoracic (cranially, fifth week) to the second sacral segments (caudally, third month) (Felix, 1912). Even by the end of the second month, the gonad is an elongated body which extends from the diaphragm to the site of the future abdominal inguinal ring (Fig. 1). Its cranial portion partially covers the suprarenal gland and its caudal pole is attached indirectly by means of the gubernaculum to the abdominal wall. It lies in front of the metanephros.

*Many authors including Stieve employ the term "germinal epithelium," but in view of the facts given it has seemed preferable to use Minot's general term, mesothelium.

In the second month, a relative decrease in the length of the testis is observable. This is accompanied by relative and absolute increases in transverse dimensions. By the third month the change in proportions is striking (Fig. 2). One even receives the impression that the testis has descended (see Figs. 1 and 2). But this is an apparent rather than a real descent, since Felix (1912) has pointed out that the cranial portion of the testis undergoes developmental involution.

Fig. 1.—Dissection of a human embryo approximately 8 weeks of age (crown-rump, 22.5 mm.). Anterior abdominal wall, liver, and umbilical loop of intestine removed. *1*, Gonad (probably ovary); *2*, genito-inguinal ligament (precursor of ligamentum teres uteri, the homologue of the gubernaculum in males); *3*, Wolffian duct; *4*, Müllerian duct; *5*, diaphragmatic suspensory ligament (primordium of suspensory ligament of the ovary); *6*, diaphragm; *7*, pleural cavity; *8*, suprarenal gland; *9*, stomach; *10*, duodenum; *11*, vitelline vein; *12*, cranial limb of primary intestinal loop (jejunal portion); *13*, caudal limb of intestinal loop (colic portion); *14*, colon; *15*, bladder; *16*, phallus. (×9.)

From the fourth to the seventh month, the testis lies in the iliac fossa at or near the internal ring (Fig. 3). In fresh fetuses (Fig. 4) it is very mobile and it enters the ring in response to slight manual pressure. Perhaps this mobility explains the different testicular levels encountered in preserved specimens of similar age (varying degrees of shrinkage during preservation influencing the level) and such questionable observations as those of Klaatsch (1890), namely that during

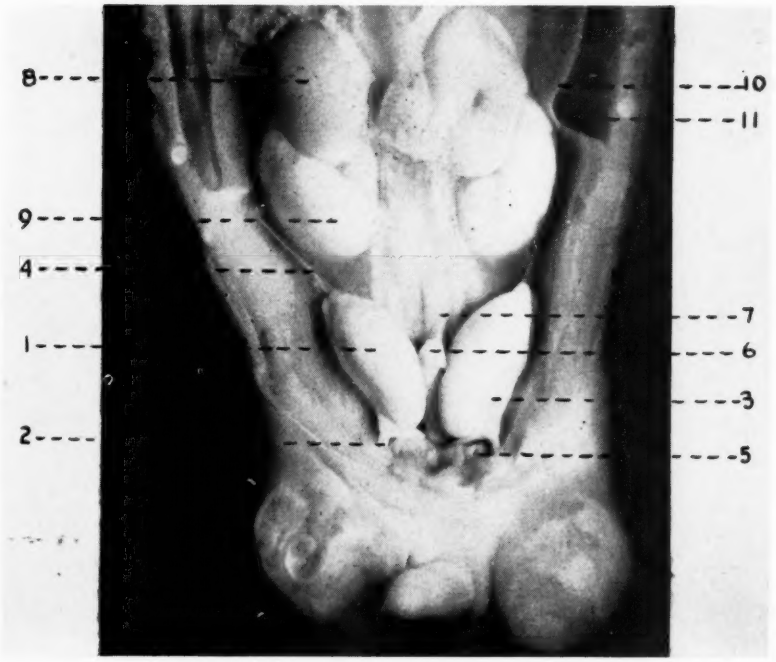

Fig. 2.—Dissection of a human embryo approximately 11 weeks of age (crown-rump, 43 mm.). Anterior abdominal wall, liver, and most of the gut have been removed, while the peritoneum covering the remaining organs is intact. *1*, Testis; *2*, gubernaculum; *3*, Wolffian duct (primordium of the epididymis and ductus deferens) situated in the degenerating mesonephros; the Müllerian duct is not visible; *4*, diaphragmatic suspensory ligament (homologue of the suspensory ligament of the ovary); *5*, umbilical artery lateral to the bladder, most of which has been removed; *6*, severed stump of colon; *7*, mesocolon; *8*, suprarenal gland; *9*, kidney (metanephros); *10*, diaphragm; *11*, pleural cavity. (×6.3.)

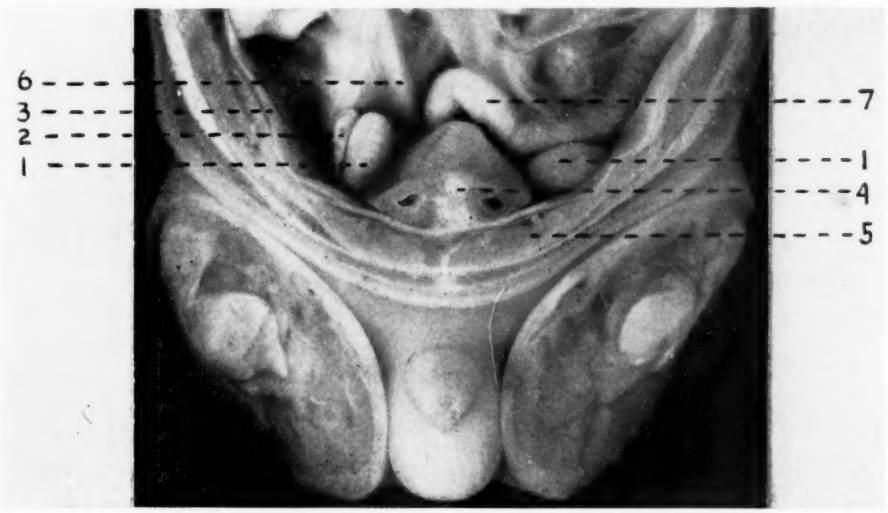

Fig. 3.—Dissection of a human fetus, almost four lunar months of age (crown-rump, 107 mm.). *1*, Testes; *2*, epididymis; *3*, peritoneum; *4*, urachus (bladder above; umbilical arteries on each side); *5*, rectus abdominis muscle (inferior epigastric vessels above); *6*, ureter; *7*, sigmoid colon. (×3.)

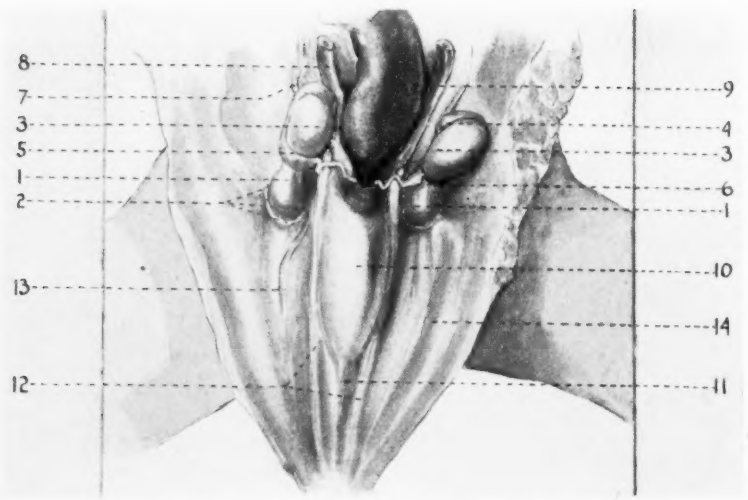

Fig. 4.—A drawing illustrating the relation of the gubernaculum to the vaginal process and to the testis in a fresh human fetus five lunar months of age (crown-rump, 167 mm., crown-heel, 242 mm.). All layers of the abdominal wall were cut beginning at the umbilicus and ending at levels near the right and left inguinal ligaments. The flap thus produced was pulled downward, thereby exposing the peritoneum. *1*, Right and left gubernacula; *2*, shallow vaginal process; *3*, testes (right testis rotated to expose epididymis); *4*, left epididymis (head); *5*, right epididymis (tail); *6*, ductus deferens; *7*, internal spermatic vessels; *8*, ureter; *9*, rectum; *10*, bladder; *11*, urachus; *12*, umbilical arteries; *13*, inferior epigastric vessels; *14*, peritoneum. (×1.4) (Drawn by Mr. Herbert Hunter from a photograph of the fresh specimen).

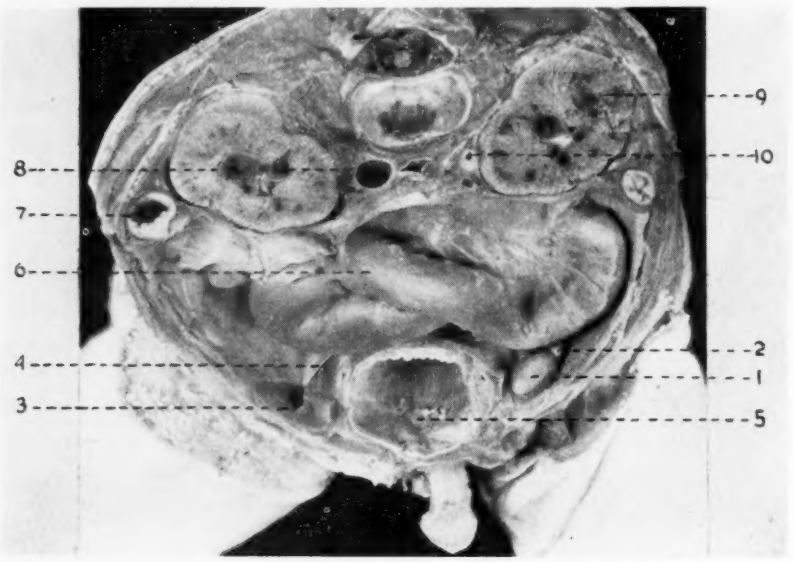

Fig. 5.—Dissection of a human fetus, seven lunar months of age (crown-rump, 26 cm., crown-heel, 36 cm.) Body sectioned at upper lumbar level. Much of anterior abdominal wall removed. *1*, Left testis at abdominal inguinal ring; *2*, epididymis (head); *3*, right abdominal inguinal ring (normally open); *4*, ductus deferens; *5*, bladder (part of fundus removed; umbilical arteries on its sides); *6*, sigmoid colon; *7*, ascending colon; *8*, inferior vena cava; *9*, kidney; *10*, ureter. Note that in this specimen the right testis has descended before the left (the reverse of the usual order.) (×1.26.)

the fourth month there occurs a temporary recession of the testis to a higher level and an invagination of the inguinal cone.

The lingering of the testis near the abdominal inguinal ring is a conspicuous, impressive phenomenon. Undoubtedly, the passage of the testis through this ring is relatively rapid.

Actual descent into the inguinal bursa (Figs. 5, 6, and 7) begins approximately at the seventh month (Bramann, 1884). The testis usually reaches its final position in the scrotum during the eighth prenatal month.

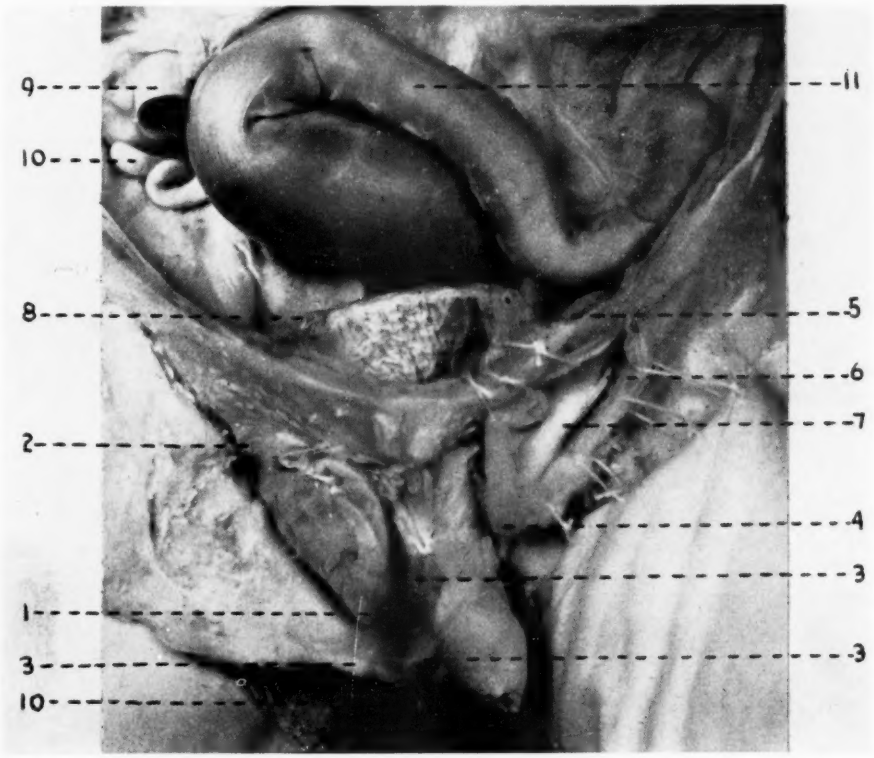

Fig. 6.—Same specimen as that in Fig. 5, with skin of anterior abdominal wall and scrotum reflected in order to expose the two inguinal bursae. *1*, Right inguinal bursa (wall incised and sutured), observe bursa's distinct inferior margin; *2*, developing subcutaneous inguinal ring; *3*, dartos tunic; *4*, left inguinal bursa (opened by single incision which was extended upward through subcutaneous inguinal ring and all layers of abdominal wall; medial flap of bursa and abdominal wall anchored by sutures through bladder; lateral flap to skin of thigh); *5*, left testis; *6*, epididymis (tail); *7*, gubernaculum; *8*, umbilical artery lateral to bladder; *9*, ileum (severed near ileo-cecal junction); *10*, vermiform process; *11*, sigmoid colon. (×1.03.)

3. *The Gubernaculum Testis* (genito-inguinal ligament).—Discovery of the human gubernaculum has been attributed by Eberth (1904) to Albrecht von Haller (1749), the great anatomist and physiologist. He called it a "vagina cylindrica"* and described it as coursing from the embryonic testis down through the abdominal wall to the inguinal region.

*Upon examining Haller's *Icones anatomicae* (1743-1749), the term "vagina cylindrica" was not found. A few pages are missing from the original volume belonging to the University of Minnesota. Dr. Shirley P. Miller, my colleague in the Department of Anatomy, has generously assisted in the search by examining his personal volume. He likewise failed to find this term.

John Hunter (1786) applied to the structure its familiar name and described it in part as follows (see also Figs. 8 and 9):

> At this time of life the testis is connected in a very peculiar manner with the parieties of the abdomen, at that place where in adult bodies the spermatic vessels pass out, and likewise with the scrotum. This connection is by means of a substance which runs down from the lower end of

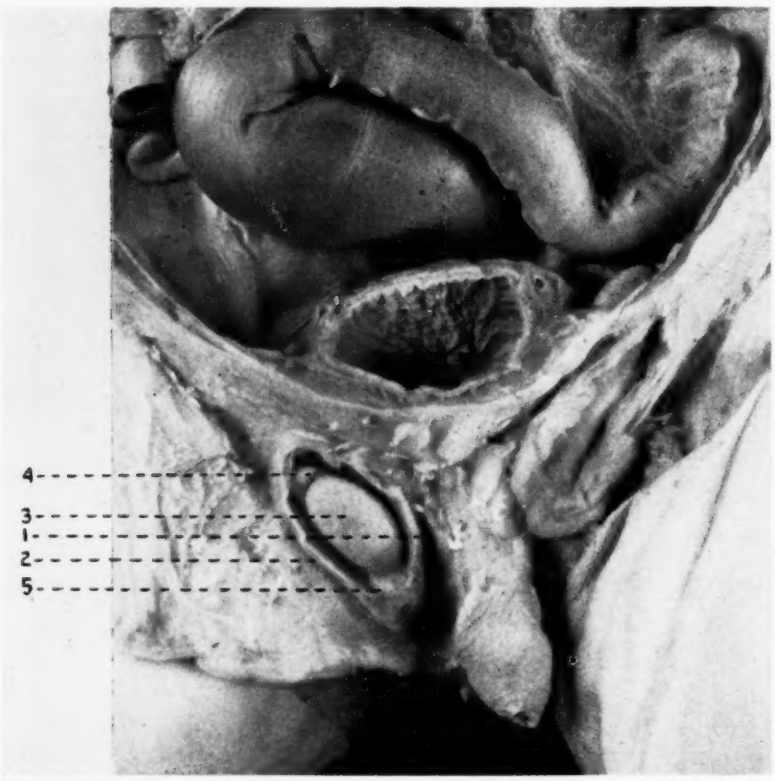

Fig. 7.—Same specimen as that in Figs. 5 and 6. The interior of the right inguinal bursa has been exposed by excising the anterior wall of the bursa. *1*, Bursa, medial wall, *2*, bursa, lateral wall; *3*, testis; *4*, epididymis, head (body and tail lie behind the testis); *5*, gubernaculum. (×1.15.)

> the testis to the scrotum, and which at present I shall call the ligament, or gubernaculum testis, because it connects the testis with the scrotum, and directs its course in its descent. It is of a pyramidal form; its large bulbous head is upwards and fixed to the lower end of the testis and epididymis, and its lower and slender extremity is lost in the cellular membrane of the scrotum. The upper part of this ligament is within the abdomen, before the psoas, reaching from the testis to the groin, or to where the spermatic vessels begin to pass through the muscles. Here the ligament runs down into the scrotum precicely in the same manner as the spermatic vessels pass down in adult bodies, and is there lost. The lower part of the round ligament of the uterus in a foetus very much resembles this ligament of the testis; and may be plainly traced down into the labium, where it is imperceptibly lost. That part of the ligamentum testis, which is within the abdomen, is covered by the peritonaeum all round, except at its posterior part, which is contiguous to the psoas, and

connected with it by the reflected peritonaeum, and by the cellular membrane. It is hard to say what the structure or composition of this ligament may be. It is certainly vascular and fibrous, and the fibers run in the direction of the ligament itself. It is covered by the fibers of the cremaster or musculus testis which is placed immediately behind the peritonaeum; this is not easily ascertained in the human subject, but it is very evident in other animals, more especially in those whose testicles remain in the cavity of the abdomen after the animal is full grown.

Fig. 8.—A photograph of one of John Hunter's original plates. (See Fig. 9.)

Early development: According to Moszkowicz (1935) the gubernaculum may be detected first in a 13.5-mm. embryo. He describes it as a ridge or fold which connects the Wolffian duct portion of the mesonephros with the abdominal wall and which lies directly in front of the umbilical artery. He considers it to be composed of moderately condensed mesenchyme that is covered with peritoneum. His observations caused him to deny the existence of two components, the "inguinal fold" and the "inguinal crest," which were said by Felix

(1912) to fuse end to end. He maintains that the cord is a single structure from the time of its first appearance.

In older specimens, the gubernaculum shifts to a position lateral to the umbilical artery and resembles a cord (Fig. 2). Since it is present before the abdominal muscles originate, the latter develop around it but in such a way that the transverse and the internal oblique layers

Fig. 9.—John Hunter's outline sketch accompanying his plate (see Fig. 8). *A*, "The upper part of the object, covered with a cloth"; *B*, thighs; *C*, penis; *D*, scrotum; *E*, "The flap of the integuments, abdominal muscles and peritonaeum, turned back over the right os ilium to bring the testis into view"; *F*, skin and tela subcutanea; *G*, "The flap of the abdominal muscles and of the peritonaeum of the left side turned back over the spine of the os ilium. The lower part of this flap is cut away, in order to shew the ligament of the testis passing down through the ring into the scrotum"; *H*, kidneys; *I*, "—projection formed by the lower vertebrae lumborum—"; *K*, "The rectum filled with meconium—"; *L*, inferior mesenteric artery; *M*, superior hemorrhoidal artery; *N*, bladder; *O*, umbilical arteries; *P*, ureters; *Q*, internal spermatic arteries; *R*, testes; *S*, vasa deferentia; *T*, "What I have called the gubernacula or ligaments of the testes in a fetus. On the left side this ligament is entire, so that it is seen going down from the lower end of the testis, through the ring of the muscle, into the scrotum but on the right side its upper and forepart is cut away, and the continuity of the epididymis and the vas deferens may be seen; and no more of the ligament is exhibited than what is situated within the cavity of the abdomen."

of the abdominal wall are interrupted by the gubernaculum, while the external oblique layer is not (Bramann, 1884). (See Figs. 13 and 14.)

Microscopic structure: Smooth muscle and connective tissue are said to be present in the gubernaculum (Frankl, 1900). However, Forssner (1928) finds no muscle and observes progressive transformation of the

gubernaculum into mucoid tissue; he says, "The usual description of descensus, that a central core of connective tissue and unstriped muscle, chorda gubernaculi, is formed in the inguinal ligament, growing down to the bottom of the scrotum and by contractions pulling the testicle down, is not founded on facts and ought to be regarded as a pure invention." It should be pointed out that Forssner's histological material was stained either by van Gieson's method, one which should assist in identifying smooth muscle and connective tissue, or with hematoxylin and eosin. Likewise, Moszkowicz (1935) notes a "loosening" of the tissue in that portion of the gubernaculum which lies at the level of the abdominal muscles (pars intermuscularis).

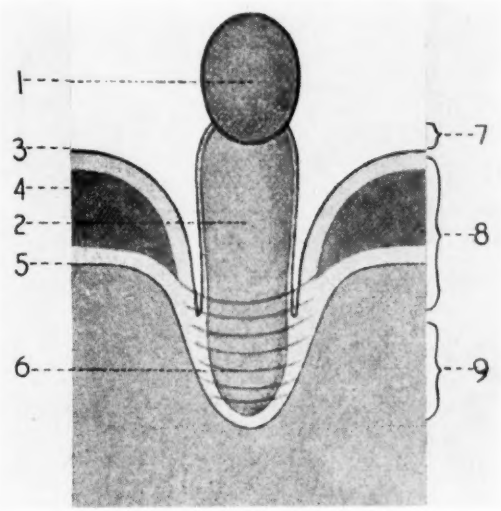

Fig. 10.—Diagram illustrating the relation of the testis to the gubernaculum and to the vaginal process previous to testicular descent. *1*, testis, *2*, gubernaculum; *3*, peritoneum; *4*, transverse and internal oblique layers of the abdominal wall; *5*, external oblique layer; *6*, cremasteric layer; 7, pars abdominalis of the gubernaculum; *8*, pars vaginalis; 9, pars infravaginalis (see text). (From Eberth, after Frankl.)

Parts: Frankl (1900) has listed three parts of the gubernaculum which are useful for dealing with anatomical aspects of testicular descent (Figs. 10, 11, and 12). Pars abdominalis extends from the cranial insertion of the gubernaculum on the epididymis to the abdominal opening of the vaginal process. Pars vaginalis stops caudally at the inferior end of the vaginal process. Pars infravaginalis terminates inferiorly between the internal oblique and the external oblique layers of the abdominal wall.

The second and third parts mentioned above have been considered as a single part and called either pars intermuscularis (Felix, 1912) or pars interstitialis (Moszkowicz, 1935).

The mesorchium and the "pars scrotalis of the chorda gubernaculi" will be considered in the following paragraphs.

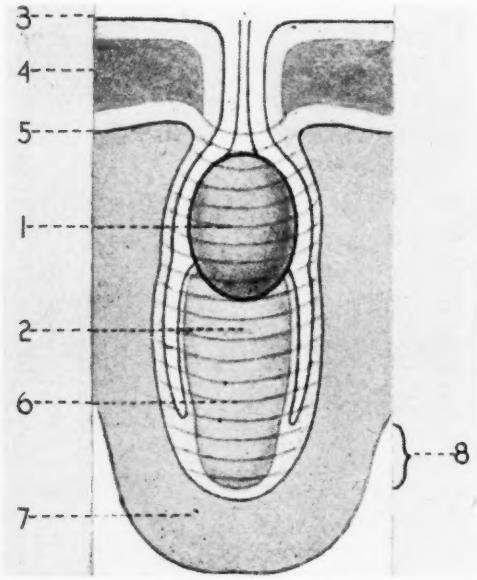

Fig. 11.—Diagram showing relations after testis enters the inguinal bursa (8-month fetus). Deeper vaginal process and shorter gubernaculum. *1*, testis; *2*, gubernaculum; *3*, peritoneum; *4*, transverse and internal oblique layers; *5*, external oblique layer; *6*, cremasteric layer; *7*, scrotum; *8*, pars infravaginalis. (From Eberth, after Frankl.)

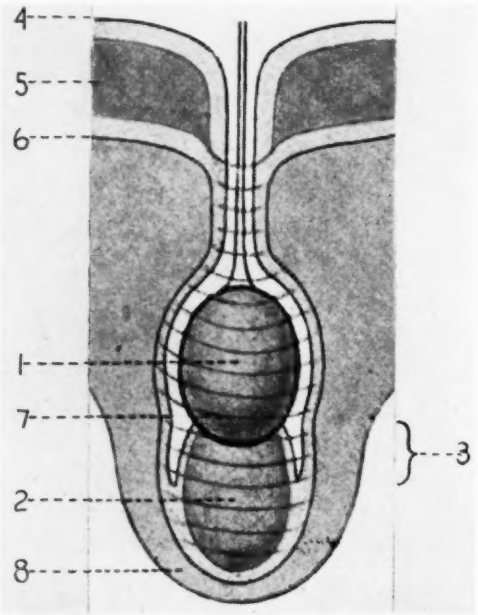

Fig. 12.—Diagram of a later stage than that shown in Fig. 11. Note the shorter pars vaginalis of the gubernaculum, and the funicular shape of the inguinal bursa. *1*, testis; *2*, gubernaculum; *3*, pars vaginalis; *4*, peritoneum; *5*, transverse and internal oblique layers; *6*, external oblique layer; *7*, cremasteric layer; *8*, scrotum. (From Eberth, after Frankl.)

Extent: There is general agreement that in the fetus the gubernaculum extends at least from the epididymis to the external oblique layer of the abdominal wall, i.e., to that portion of this layer which becomes definitely the external spermatic fascia. Also, it is agreed that the testis is attached indirectly to the gubernaculum by means of the mesorchium. The latter, frequently called the ligamentum testis, is a structure affording direct connection between the testis and the epididymis.

However, extension of the gubernaculum into the scrotum, as advocated by Hunter, is questionable. In dissections of fresh and of preserved fetuses, it has not been possible to identify gubernacular tissue inferior to the distal end of the external spermatic fascia in which respect the present observations confirm those of Bramann (1884), Klaatsch (1890), Frankl (1900), and Forssner (1928). Yet, perhaps, its existence should not be denied until more detailed investigations have been made.

Favoring the presence of a pars scrotalis of the gubernaculum are such investigators as Lockwood (1888), Moszkowicz (1935) and Felix (1912). The former maintains that distinct bands of "muscular fibers of the gubernaculum" are attached as follows: (1) to the pubis, (2) to the scrotum, (3) to the root of the penis, (4) to the perineum, and (5) to Scarpa's triangle. Although his evidence fails to convince one of the existence of muscular bands, he believed that such bands are related to various ectopic positions of the testis. The second investigator describes a "pars subcutanea" of the gubernaculum. This structure apparently represents subcutaneous connective tissue and perhaps should be considered as such rather than as part of the gubernaculum, since in fetuses larger than 43 mm. inadequate evidence is presented for the occurrence of an aperture in the external oblique layer through which the so-called "pars subcutanea" is continuous with the gubernaculum. The third investigator diagrams a "pars scrotalis" in a 26.5-mm. embryo which he considers to be the caudal segment of a "chorda gubernaculi."

In young embryos of the Minnesota collection a cellular condensation inferior to the external oblique layer can be demonstrated in serially sectioned specimens. But it remains questionable whether in older fetuses this condensation becomes a recognizable part of the gubernaculum.

Eventually, if it can be established definitely that the gubernaculum terminates superior to the external oblique layer instead of in the scrotum, it may be desirable to replace Hunter's term, "gubernaculum," with Waldeyer's term (1899), "genito-inguinal ligament."

Variations in size: While no extensive series of measurements of the gubernaculum have come to the writer's attention, gross inspection would lead one to infer that all dimensions of the gubernaculum in-

crease progressively until the seventh month (Figs. 2, 4, and 6).* Immediately preceding descent of the testis, i.e., at the beginning of the seventh month (Klaatsch, 1890), the diameter of the gubernaculum equals or exceeds the combined diameters of the testis and the epididymis (Forssner, 1928; Moszkowicz, 1935).

During the process of testicular descent, the gubernaculum becomes shorter and shorter but not wider (see Figs. 10, 11, and 12). According to Eberth (1904), respective lengths and diameters at various prenatal ages are as follows: second month, 1.0 by 0.5 mm.; beginning of seventh month, 12.0 by 3.0 to 8.0 mm.; end of seventh month, 6.0 by 2.0 mm.; after seventh month (when descent is almost completed), 3.5 by 2.0 mm. In the preserved specimens shown in Figs. 2, 4, and 6, the measurements were, respectively, 0.4 by 0.2 mm. (left) and 0.3 by 0.2 mm. (right); 5.1 by 2.3 mm. (left) and 5.0 by 2.5 mm. (right); 16.6 by 4.8 mm. (left) and 2.9 by 5.1 mm. (right).

Generally at birth the gubernaculum is small and inconspicuous; in adult subjects vestiges of it, if recognizable, are indistinct.

4. *Origin of the Scrotum.*—There is disagreement concerning this. As reported by Felix (1912), the scrotum is derived from an unpaired scrotal area which is situated between the anus and the base of the penis; and the labioscrotal swellings (paired genital swellings) disappear by contributing to the skin and its underlying layers at the base of the penis. This is contrary to an older view which maintains that the scrotum originates from the paired labioscrotal swellings. This older view has received new support from such recent investigators as Spaulding (1921) and Saunders, Rusk, Lowenstein, and Silverberg (1942). The former states that these swellings become distinguishable at the 19-mm. stage, that at first they lie lateral to the developing phallus, then migrate caudally and finally fuse to produce right and left halves of the scrotum. According to the latter investigators and to Moszkowicz (1935), the primordia of the scrotum lie originally in front of the penis.

Anomalous dislocations of the phallus (Francis, 1940; Meyer, 1941; Saunders, Rusk, Lowenstein, and Silverberg, 1942) support the view that the scrotum originates rostrally to the penis.

5. *Development and Fate of the Inguinal Bursa.*—The name for this fetal sac was introduced by Klaatsch (1890). In males the proximal portion of the sac becomes the spermatic cord of the adult and the distal portion, the part in which the peritoneum is retained, the spermatic sac.† Precursors of the following definitive layers compose the wall of

*See addendum.

†This is a term coined by Dr. Edward A. Boyden in his teaching of medical students to designate that part of the bursa which contains the testis. It is used for two purposes: (1) as a companion term to "spermatic cord" and (2) to emphasize the fact that as outpocketings of the abdominal wall the spermatic sacs are to be considered in a different category (both anatomically and embryologically) from the scrotal sacs which are outpocketings of the skin and tela subcutanea. In fact, the two sacs can be easily separated by blunt dissection, being only loosely connected by areolar tissue.

the bursa: the external spermatic fascia (intercolumnar fascia), the middle spermatic fascia (cremasteric muscle and fascia), the internal spermatic fascia (infundibuliform fascia or tunica vaginalis communis), and the peritoneum (tunica vaginalis proprius).

Origin of the vaginal process: This evolution of the peritoneum, discovered by Camper (according to Effler, 1935), originates at a time when there are no external manifestations of a bursa (Fig. 13). It represents an inferolateral portion of the coelom which appears grossly to have been pushed out by the gubernaculum testis.

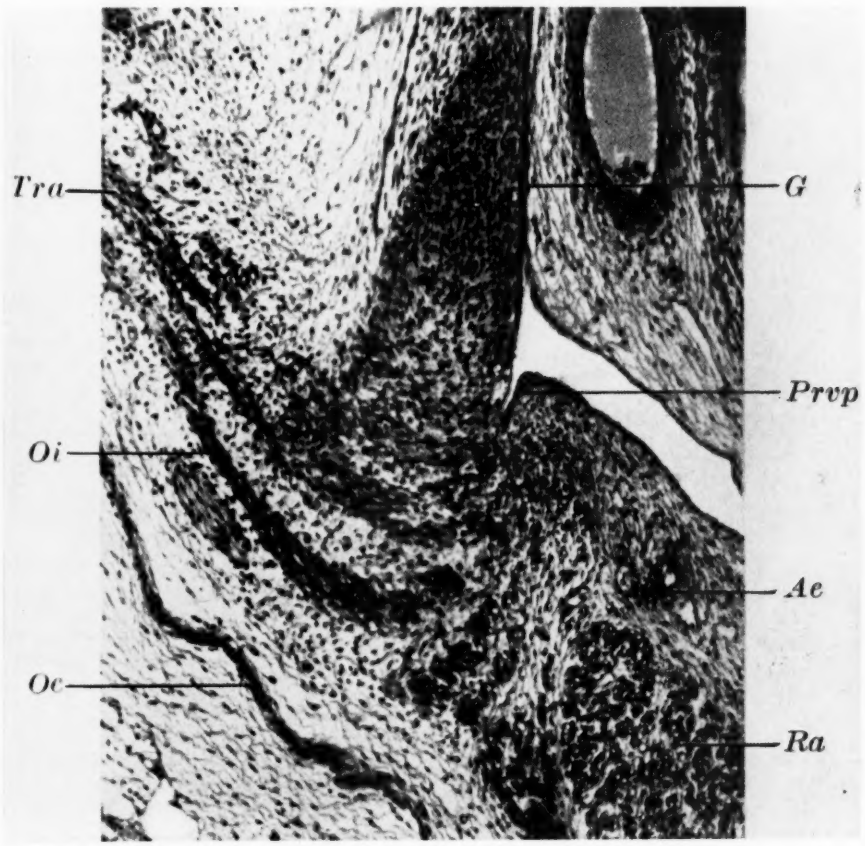

Fig. 13.—Transverse section through the abdominal wall of a 36.3-mm. human embryo, to illustrate the origin of the processus vaginalis peritonei (*Prvp*) and its relation to the gubernaculum (*G*) and the layers of the abdominal wall. The large vessel (upper right) is the umbilical artery; *Ae*, inferior epigastric artery; *Oe*, external oblique layer; *Oi*, internal oblique layer; *Ra*, rectus abdominis muscle; *Tra*, transverse abdominal layer. (×89.) (From Moszkowicz, 1935.)

The factors involved in its formation have not been adequately determined. Among several interpretations two are chosen to illustrate the complexity of the problem. Felix (1912) maintains that the shifting of the umbilical artery from a horizontal to a vertical plane is the chief factor. After this shifting, which results from growth of the anterior abdominal wall, the artery and its peritoneal covering provide

an incomplete partition between the vaginal process and the embryonic pelvis. Moszkowicz (1935), on the other hand, believes that the vaginal process originates in response to an active muscular contraction within the inguinal cone, this contraction stretching the peritoneum via the gubernaculum. His interpretation is a modification of one previously published by Klaatsch (1890).

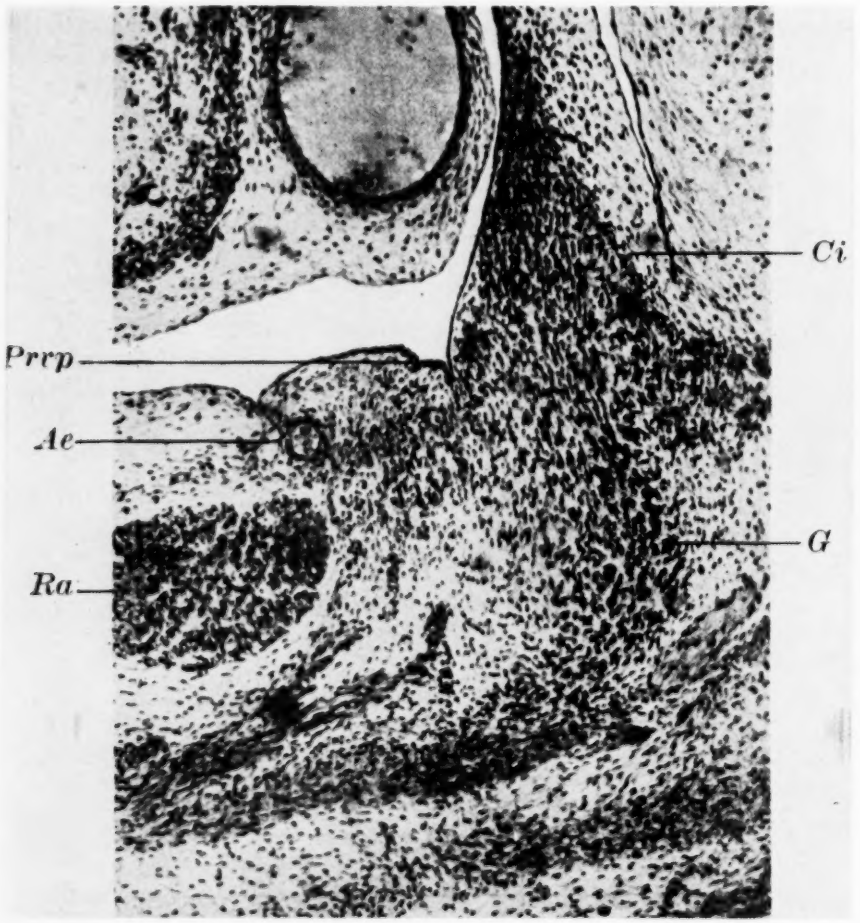

Fig. 14.—Transverse section through the abdominal wall of a 43-mm. human embryo. On the right (below legend *Ci*), the transverse and the internal oblique layers blend with the gubernaculum to form the inguinal cone. *Ae*, Inferior epigastric artery; *Ci*, inguinal cone; *G*, gubernaculum; *Ra*, rectus abdominis muscle. (×89.) (Moszkowicz, 1935.)

Until the fifth fetal month, the vaginal process is a small structure, being approximately 1 mm. in length (Frankl, 1900). Except dorsally, it surrounds the pars vaginalis of the gubernaculum (Figs. 4, 10, 13, and 15).

The inguinal cone: This cone is formed when the gubernaculum is invaded by skeletal muscle from the transverse and internal oblique layers of the abdominal wall (Frankl, 1900; Moszkowicz, 1935). Klaatsch

(1890) describes and illustrates the cone as a prominent structure which, in human fetuses as in rodents, first pushes upward and then is retracted downward. But this is not confirmed by Frankl (1900), who reports the cone to be rudimentary in man (Fig. 14).

Evagination of the abdominal wall: Previous to testicular descent, the abdominal wall becomes evaginated to produce the inguinal bursa. The general features of this process are illustrated admirably in a paper by Bramann (1890).

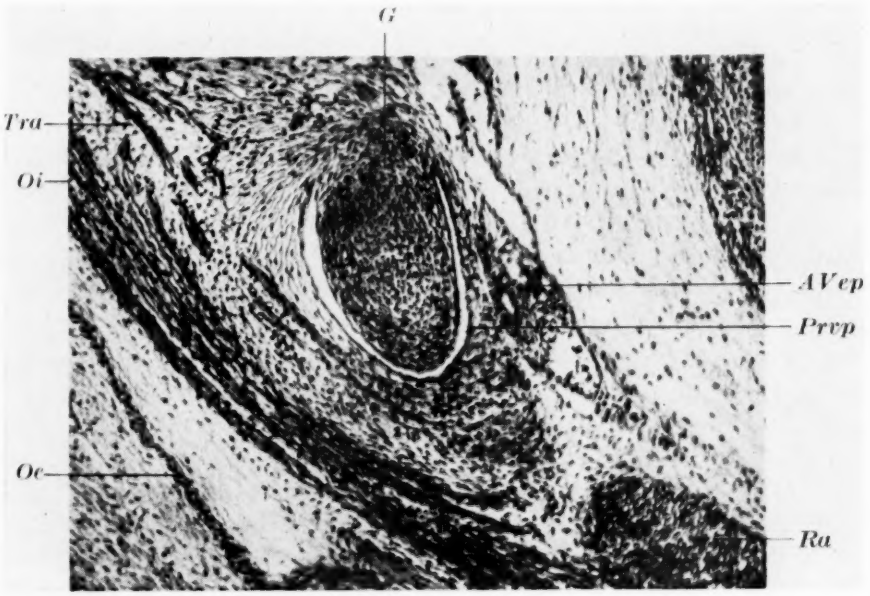

Fig. 15.—Photomicrograph of a section of a 41-mm. human embryo, showing the gubernaculum and the vaginal process in transverse section. Note that dorsally (up in photo) the gubernaculum is not surrounded by peritoneum of the vaginal process. *AVep*, Inferior epigastric artery and vein; *G*, gubernaculum; *Oe*, external oblique layer; *Oi*, internal oblique layer; *Prvp*, processus vaginalis peritonei; *Ra*, rectus abdominis muscle; *Tra*, transverse abdominal layer. (×89.) (Moszkowicz, 1935.)

It is said that even by the fourth month the external oblique layer is slightly evaginated and that by the fifth month the apex of this layer reaches the upper part of the scrotum (Frankl, 1900). However, in the specimens available to the writer, no evagination was observed before the sixth lunar month.

In the formation of a bursa, the gubernaculum and the vaginal process become longer with the result that their caudal ends lie nearer the scrotum. They carry with them the fibromuscular layers of the abdominal wall, since these layers are fused to the rudimentary inguinal cone. Some anatomists think that the gubernaculum and the vaginal process pass through an aperture which already exists in the abdominal wall. But, if the external oblique layer lacks an aperture (Bramann, 1890; Frankl, 1900), it must be everted either by the pars infravaginalis of the gubernaculum or, perhaps more precisely, by the

rudimentary inguinal cone (Figs. 10 and 14). In any event, the external oblique layer is the fetal precursor of the external spermatic fascia.

The orifice of the bursa: In order for the testis to descend, the orifice of the inguinal bursa must be large enough to admit the testis and its associated structures. As though "anticipating" testicular descent, the orifice becomes sufficiently large. Some authors state that this is caused in part by an increase in the diameter of the gubernaculum (Forssner, 1928; Moszkowicz, 1935) rather than by an expansion of the inguinal cone (Klaatsch, 1890). Frankl (1900), even while maintaining that the cone is rudimentary, believes that it increases the diameter of the vaginal process.

Fate of the bursa: After the testis descends, the bursa's superior part becomes funicular and later forms the spermatic cord. Its inferior part persists as the spermatic sac.

The funicular portion of the vaginal process becomes obliterated after birth, nearly always during the first postnatal year; thus, the communication is lost between the vaginal process and the peritoneal cavity. From the data of other investigators (Sachs, 1887; Engel, 1857), Scammon (1923) has concluded that more than 80 per cent of the cases between the tenth and twentieth postnatal days show partial or complete obliteration. Usually the obliterative changes are completed earliest on the left side of the body. The regression is said to begin at two points, namely, near the abdominal inguinal ring and near the superior margin of the testis (Lockwood, 1888). However, in a larger number of specimens (Engel, 1857; Sachs, 1887; Frankl, 1895) it has been observed to begin in the middle third of the funicular portion and to advance rapidly upward and downward from this level. Final disappearance of the funicular portion is accomplished by the formation of granulation tissue (Pellacani, 1884).

6. *Growth of the Testis.*—The ponderal growth of the testis in the fetal period is similar to that of the body as a whole (Wald and Scammon, 1932). But the relative weight of the testis, in comparison with body weight, becomes reduced during this interval from 0.143 per cent at the third lunar month to 0.023 per cent at birth. Since the experimental induction of testicular descent is associated with an increase in the size of the testes (see Hormonal Considerations), it is reasonable to suppose that in man normal prenatal descent is influenced by rapid testicular growth, especially during the seventh lunar month. However, concerning this point, the data are insufficient to warrant a positive conclusion; at the end of the seventh month and in fetuses having similar body weights, the weights of the testes range from less than 0.2 to approximately 0.6 Gm. (Wald and Scammon, Fig. 1).

The question should be raised as to whether the interruption of the supply of placental and/or maternal hormones at birth causes a tem-

porary postnatal recession in the size of the testis. A definite answer cannot be given; yet the available data (Table I, last vertical column)* suggest that the weight of the testes decreases slightly during the first three postnatal months. Reasons for refraining from an affirmative

TABLE I

SUMMARY OF DATA ON THE WEIGHT OF THE TESTES IN THE PRENATAL AND POSTNATAL PERIODS*

DATA OF CASTALDI AND VANNUCCI (1926) TOTAL N = CA. 100†			DATA OF ROESSLE AND ROULET (1932) TOTAL N = 775			COLLATED DATA TOTAL N = 1734‡		
AGE INTERVAL	N	TESTES WEIGHT (GM.)	AGE INTERVAL	N	TESTES WEIGHT (GM.)	AGE INTERVAL (LUNAR MONTHS)	N	TESTES WEIGHT (GM.)
The Prenatal Period								
----------	---	----	----------	---	----	3 to 4	3	0.01
----------	---	----	----------	---	----	4 to 5	7	0.10
----------	---	----	----------	---	----	5 to 6	5	0.10
----------	---	----	----------	---	----	6 to 7	16	0.16
----------	---	----	----------	---	----	7 to 8	7	0.28
----------	---	----	----------	---	----	8 to 9	19	0.37
----------	---	----	----------	---	----	9 to 10	18	0.53
----------	---	----	----------	---	----	Postmature	15	0.79
The Postnatal Period								
Birth	---	0.30	Birth	15	1.41	Birth	122	0.91
Birth to 5 mo.§	---	0.71	Birth to 6 mo.§	21	1.56	Birth to 3 mo.§	6	0.74
3 to 6 mo.	---	1.21	6 mo. to 1.5 yr.	19	1.95	3 to 6 mo.	15	1.01
						6 to 12 mo.	11	1.19
1 to 2 yr.	---	1.93	1.5 to 2.5 yr.	4	1.98	1 to 2 yr.	16	1.30
2 to 5 yr.	---	1.53	2.5 to 6.5 yr.	12	2.86	2 to 4 yr.	33	2.29
						4 to 6 yr.	7	2.33
5 to 10 yr.	---	1.82	6.5 to 12 yr.	12	2.90	6 to 8 yr.	23	3.24
						8 to 10 yr.	23	1.65
10 to 15 yr.	---	7.17	12 to 18 yr.	15	20.55	10 to 12 yr.	13	2.00
			18 to 19 yr.	15	27.70	12 to 15 yr.	18	6.89
15 to 20 yr.	---	28.38	19 to 20 yr.	35	30.70	15 to 20 yr.	66	27.61
20 to 30 yr.	---	28.28	20 to 30 yr.	314	33.28	20 to 30 yr.	859	34.18
30 to 40 yr.	---	27.17	30 to 40 yr.	169	37.70	30 to 40 yr.	198	36.25
40 to 50 yr.	---	27.05	40 to 50 yr.	113	36.56	40 to 50 yr.	129	25.25
----------	---	----	50 to 60 yr.	36	33.84	50 to 60 yr.	44	32.50
----------	---	----	20 to 60 yr.	632	35.08	20 to 60 yr.	1280	34.53
----------	---	----	60 yr. and over	14	35.43	60 yr. and over	18	34.52

*Collated from 16 sets of data published by other observers [4, 6, 7, 13, 17, 57, 65, 71, 82, 96, 103, 105, 128, 131, 132, 135], and from unpublished observations of H. Mackeen, D. C. Mebane, and R. E. Scammon. Observations from printed sources included only after critical examination of the original publications. Total N = ca. 1900.

Postmature is defined as stillborn newborn infants, or infants dying in the first 48 hours after birth, having a body length CH of 52 cm. or over and/or a (dead) body weight of 3600 Gm. or over. *Birth* is defined as stillborn newborn infants, or infants dying in the first 48 hours after birth, having a body length CH of 48 to 52 cm. and/or a (dead) body weight of 2500 to 3600 Gm. *Age* in the prenatal period is calculated from empirical formula[2] of Scammon and Calkins (1923).

†No N's indicated in the publication of Castaldi and Vannucci (1926), but internal evidence indicates that there were over 100 observations in this series.

‡The N's and means of the several sets of collated data for birth and from 18 years forward include the values given by Roessle and Roulet (1932).

§Calendar months.

*I wish to express my indebtedness to Dr. Richard E. Scammon for the privilege of using four tables from his forthcoming book, *Human Growth and Structural Development*, Vol. III, The Commonwealth Fund, New York.

answer include the following: (1) there are relatively few observations during these months, (2) the average weight of the testes during this period (0.74 Gm.), although less than at birth (0.91 Gm.), is almost identical with that of "postmature" newborn infants (0.79 Gm.) and (3) it is uncertain whether in this period some of the data involve premature infants.

During postnatal life, three phases of testicular growth have been recognized (Scammon, 1930). In the first phase, extending through infancy, the testis shows a distinct increase in size. In the second phase, extending approximately from the latter part of the first to the end of the tenth years, the testis grows relatively little. The third phase extends into the third decade. During all except the latter part of this phase, the testis exhibits rapid growth (Tables I to III). Testicular growth during the circumpuberal period is stimulated undoubtedly by hypophysial gonadotropic hormones. It is an interesting fact that the weight of the testis is rather uniform during the adult

TABLE II

DIMENSIONS OF THE TESTES IN THE POSTNATAL PERIOD*

AGE INTERVAL	N	DIMENSIONS (MEANS OF RIGHT AND LEFT TESTES)		
		LENGTH (MM.)	BREADTH (MM.)	THICKNESS (MM.)
Birth	19	11.0	6.6	5.5
Birth to 3 mo.	23	12.9	7.3	5.6
3 to 6 mo.	15	14.5	8.0	6.0
6 to 12 mo.	9	14.9	8.9	7.2
1 to 2 yr.	11	15.2	9.1	8.2
2 to 5 yr.	14	15.6	7.9	7.3
5 to 10 yr.	20	16.0	9.7	9.0
10 to 12 yr.	10	18.0	11.2	9.2
12 to 15 yr.	12	27.7	16.1	14.6
15 to 20 yr.	13	39.0	31.5	20.0
Maturity (20 to 60 yr.)	40	42.0	38.0	25.0

*Based on the data of Sappey, 1876, Vvedenski, 1900, and Mita, 1914. Observations included only after critical examination of the original publication. Total N = 186.

TABLE III

DIMENSIONS OF THE TESTES IN THE LIVING IN THE POSTNATAL PERIOD*

AGE INTERVAL	N	RIGHT TESTIS		LEFT TESTIS	
		LENGTH (MM.)	BREADTH (MM.)	LENGTH (MM.)	BREADTH (MM.)
Birth to 3 mo.	24	16	8	16	8
3 to 6 mo.	17	17	8	16	8
6 to 12 mo.	30	16	8	16	8
1 to 5 yr.	56	16	8	17	8
5 to 10 yr.	52	17	9	17	8
10 to 11 yr.	11	17	9	17	9
11 to 12 yr.	8	19	9	20	10
12 to 13 yr.	7	23	12	23	12
13 to 14 yr.	6	28	14	28	14
14 to 15 yr.	6	28	14	29	15
15 to 16 yr.	4	35	20	36	20

*From the data of Reich, 1924. Total N = 221.

period, even including the years of senility. This correlates with the absence of distinct climacteric manifestations in most senile men.

From birth to maturity, the increase in the weight of the testes (about thirty-seven fold) is relatively almost twice as great as that of the body (about twenty fold) and most of its parts. Apparently this style of growth is limited to the reproductive organs and their auxiliary structures (Scammon, 1930).

7. *Histologic Considerations.*—

The testis: Seminiferous tubules, at birth, measure 60 to 80 micra in diameter (Table IV); they exhibit many undifferentiated cells and few spermatogonia (Spangaro, 1902; Mita, 1914). Until the time of approaching puberty, they lack real lumina (Cooper, 1929). The tubules contain no spermatocytes during the tenth year, several spermatocytes during the eleventh year, spermatids by the thirteenth year, and spermatozoa as early as the fourteenth year (Mott, 1919; Cooper, 1929). Frequently spermatozoa are present after the seventh decade of life (Engle, 1939). Large numbers of spermatozoa have been reported in a man 94 years of age (Seymour, Duffy, and Koerner, 1935).

TABLE IV

DIAMETER OF THE CONTORTED (SEMINIFEROUS) TUBULES AT SEVERAL AGE PERIODS*

AGE PERIOD	DIAMETER (μ)
Shortly after birth	60 to 80
Before puberty	110 to 120
At the close of puberty	140 to 170
During maturity	180 to 220
At senility	200 to 260

*Data of Spangaro, 1902.

The interstitial cells of the testis are numerous during the fourth and fifth fetal months. A decline in the amount of interstitial tissue has been reported to occur between the fifth month and birth (Felix, 1912); but Mita (1914) maintains that this is apparent, rather than actual, because tubular tissue is acquiring greater quantitative predominance. In a child 4 months of age, the interstitial cells are said to be fewer and smaller than at the time of birth (Mott, 1919).

Rasmussen (1932) has written an extensive account of the interstitial cells. They present an epithelioid appearance and a polygonal shape. They occur singly or in irregular groups. Their cytoplasm contains near its periphery such lipids as phospholipin, glycolypin, cholesterol and its esters, and probably neutral fats. Centrally the cytoplasm exhibits secretion-like granules. These are most conspicuous in normal hypertrophic cells.

The scrotum: The wall of this structure consists of skin, cutaneous appendages, smooth muscle, and connective tissue. Fat is scarce or absent, while sweat glands are abundant. The epidermis is thin.

According to Eberth (1904), two layers of smooth muscle are present. The outer layer, consisting of circular fibers and belonging to the dermis, is the thinner. It extends across the raphe. The inner layer contains longitudinal and oblique fibers; it constitutes the greater part of the subcutaneous layer and is known as the dartos tunic; from right and left sides, some of its fibers are reflected to form the scrotal septum which separates the scrotum into paired scrotal sacs. The dartos tunic is attached to the spermatic sacs by means of loose connective tissue which is called the intermediate stratum and which represents the non-dartos portion of the subcutaneous tissue.

HORMONAL CONSIDERATIONS

1. *Gonadotropins.*—The gonadotropins are hormones which stimulate the testes (and the ovaries). Those occurring in the anterior hypophysis are called hypophyseal* gonadotropins. Pioneer investigations concerning them were made by Smith (1927) and by Smith and Engle (1927).

The gonadotropic hormones (gonadotropins) are thought to be produced by the hypophysis: the gametogenic hormone (thylakentrin or follicle-stimulating hormone) and the interstitial cell-stimulating hormone (metakentrin or luteinizing hormone). Reviews of this subject have been written by Fevold (1939) and by Engle and Levin (1941). The latter authors point out the reasons why the existence of two hypophyseal gonadotropins is difficult to prove. The gametogenic hormone is reported to stimulate the seminiferous tubules and to have no effect upon the interstitial cells (Greep, Fevold and Hisaw, 1936; Greep, van Dyke and Chow, 1942). But the interstitial cell-stimulating hormone stimulates not only interstitial cells but also seminiferous tubules as well (Greep and Fevold, 1937; Greep, van Dyke and Chow, 1942; Simpson, Li and Evans, 1942). A tentative explanation for the action of the latter hormone on the tubules is that endogenous androgen, released by interstitial cells in response to the hormone, stimulates the tubules.

Other gonadotropins are present in the body fluids of pregnant animals. Apparently they are produced by the chorion rather than by the hypophysis, hence they are called chorionic gonadotropins. Still other gonadotropins, appearing in the urine of normal men and women and of menopausal subjects, are designated as urinary hypophyseal gonadotropins. Chorionic and urinary hypophyseal gonadotropins are believed to contain both gametogenic and interstitial cell-stimulating hormones; but the indications are that the former gonadotropin contains mostly interstitial cell-stimulating hormone and that the latter consists chiefly of gametogenic hormone.

Gonaodtropins act directly on the testes. By causing the testes to secrete androgen, they stimulate indirectly such accessory reproductive organs as the scrotum and the ductus deferens.

*Corner (1943) has written a note concerning the spelling of this adjective.

2. *The Effects of Injecting Gonadotropins.—*

Descent of the testis: This has been induced in prepuberal monkeys* by injecting either hypophyseal or chorionic gonadotropin (Engle, 1932b; Aberle and Jenkins, 1934), and in adult hypophysectomized monkeys by injecting the latter hormone (Smith, 1938).

Many investigators have observed the effects of gonadotropins on the testes of immature rats. Generally they have not mentioned whether precocious descent occurred. This is readily understandable because in normal immature rats the position of the testes is so variable that the identification of precocious descent is difficult; upon handling normal immature rats, the testes move freely upward and downward. But it has been noted frequently that in animals receiving gonadotropins, the scrota are larger than those of controls.

Descent has been obtained in ground squirrels by injecting either hypophyseal, urinary hypophyseal, or chorionic ganodatropin (see beyond). These wild rodents are favorable animals for such observations because in them complete descent does not occur normally until eight or more months after birth.

There is bountiful literature concerning the clinical induction of descent by means of gonadotropins. Since this literature has been reviewed in December, 1942 (Pullen, Wilson, Hamblen and Cuyler), only brief comments seem to be desirable. From the earlier papers, Engle (1936) noted that chorionic gonadotropin had been reported to cause the descent of "undescended testes" in 119 of 172 cases. Undoubtedly, this high percentage (69.1 per cent) is due to many inaccurate diagnoses previous to therapy.† Thompson and Heckel (1939a), excluding from their data the patients with "migratory"‡ testes, reported fewer positive responses (about 20 per cent). Orchidopexies were performed on eleven patients whose testes failed to descend. In each of these patients, anatomical barriers to descent were observed during the operation. Thompson and Heckel believe that perhaps gonadotropins cause descent only in those individuals whose testes would descend, without treatment, near the time of puberty.

Testis as a whole: The testes of experimental animals respond to gonadotropins by growing. Although variable in different animals receiving identical amounts of hormone, testicular growth tends to vary directly with the quantity of hormone which is given. Thus, in monkeys receiving hypophyseal or chorionic gonadotropin, weights of the testes were doubled (Engle, 1932a). In rats injected with chorionic gonadotropin (Moore, 1936) and in ground squirrels injected with urinary hypophyseal gonadotropin (Wells and Overholser, 1938),

*According to Engle, normal closure of the abdominal inguinal ring had occurred before injections were begun. Subsequently, however, Wislocki (1933) reported that in juvenile monkeys this ring frequently is open.

†Methods for making better diagnoses are outlined by Thompson and Heckel (1939a) and by Hamilton (1941).

‡"Migratory" testes are defined by these investigators as those "which move back and forth readily from the canal to the scrotum."

weight of the testes of some animals increased more than 400 per cent.

The growth is due to hypertrophy of the seminiferous tubules, of the interstitial tissue, or of both.

Seminiferous tubules: Growth of the tubules has been reported consistently in animals receiving gonadotropins. The growth undoubtedly causes an increase in the size of the testis and it may occur even in the absence of spermatogenetic acceleration. As might be expected, however, the greatest tubular growth is to be observed in animals which respond to gonadotropins by producing spermatozoa.

As may be inferred from the above remarks, the gametogenic response to gonadotropins is variable in different species. Clinical observations on the subject deal largely with the quantity and quality of spermatozoa in patients receiving various gonadotropins.* The majority of these observations may be interpreted as evidence that in man injections of gonadotropins cause gametogenic responses.

Among mammals, the precocious production of spermatozoa in response to gonadotropins has been observed only in one species—the ground squirrel. It has been induced by adequate treatments with the following materials which contain hypophyseal, urinary hypophyseal, of chorionic gonadotropins: fresh hypophyses (Wells, 1935a; Wells and Gomez, 1937a), urine of pregnant women, antuitrin S (Wells, 1935a), blood serum from pregnant mares (Wells and Moore, 1936; Wells, 1935b, 1937) and prospermin (Wells and Overholser, 1938). But in animals such as the monkey (Engle, 1932a) and the rat, provided a reliable criterion for judgment is used (Moore, 1936; Zondek, Brzezinski, and Sulman, 1941), gonadotropins fail to induce the precocious formation of spermatozoa.

It seems reasonable that differences in age may explain in part the differing responses elicited in prepuberal ground squirrels and rats, the former animals being older than the latter. Indeed, other investigators have reported observations which support this idea. Smith and Leonard (1933) demonstrated that chorionic gonadotropin will maintain spermatogenesis in adult hypophysectomized rats or repair the damage caused by hypophysectomy, thus showing that rats may respond to gonadotropin when they have reached an appropriate age or when their tissues have become sufficiently differentiated. Leathem and Webster (1942) reported similar results in adult guinea pigs. Also, it has been noted that urinary hypophyseal gonadotropin can induce complete spermatogenesis in rats which are hypophysectomized near the time of puberty, allowed to go without treatment for several days, injected for several weeks, and killed at the approximate age of 60 to 70 days (Leathem, 1940; Leathem, and Mills, 1942). It may be pointed out that with aging the immature ovary is known to gain responsiveness to gonadotropins (Smith and Engle, 1927). In addition

*Eighteen clinical papers concerning this topic are available in the bibliography prepared by Pullen, Wilson, Hamblen, and Cuyler, 1942.

to age, the duration of treatment may help to explain the different responses, several weeks being required for the production of spermatozoa. Length of the prepuberal period permits this duration to be longer in immature ground squirrels than in immature rats.

The situation in prepuberal monkeys is less clearly understood. But there is evidence that the age of the animals and the duration of treatment are not the only factors responsible for the lack of response in monkeys. For Smith (1938) has shown that in an immature hypophysectomized monkey weighing 4040 Gm., twenty-nine daily injections of chorionic gonadotropin fail to stimulate spermatogenesis. In adult hypophysectomized monkeys, this gonadotropin provides imperfect restoration of spermatogenesis in testes which have undergone involution; although when injected immediately after hypophysectomy, the gonadotropin maintains spermatogenesis for twenty days but not for longer periods of time (Smith, 1942). It is not known, therefore, why this species is refractory to gonadotropins but the possibility exists that antigonadotropins may be involved.*

Interstitial tissue:† Certain gonadotropins cause conspicuous increases in this tissue (Steinach and Kun, 1928; Engle, 1929; Moore, 1936) and, consequently, growth of the testes.

The responses of the interstitial tissue to various gonadotropins have been reviewed by Engle and Levin (1941). Two criteria are useful for identifying positive stimulation by gonadotropins. The first is an anatomical criterion which may be either a hypertrophy of the interstitial cells or an unquestionably significant increase in the amount of interstitial tissue.‡ The second criterion, an indirect one, consists of an increase in the size of accessory reproductive organs such as the seminal vesicles and the prostate. It is based upon the generally accepted view§ that the interstitial cells produce androgen which is known to stimulate the accessory reproductive organs of males. Through the use of these criteria, the observations indicate that the interstitial tissue may be stimulated by all gonadotropic preparations except those containing predominately the gametogenic hormone (follicle-stimulating hormone or thylakentrin).‖

Scrotum and ductus deferens: These accessory reproductive structures also grow in response to gonadotropins. However, as mentioned previously, they respond indirectly to gonadotropins, the androgen produced by the testes being the stimulating agent.

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*Many observations suggest that antigonadotropins are immune bodies which originate in response to foreign proteins, while other observations do not support such an interpretation. Discussions of this subject have been published recently (Thompson, Collip, and Selye, 1941; Zondek and Sulman, 1941).

†The interstitial tissue of the testis decreases after hypophysectomy (Smith, 1932), i. e., when the hypophyseal interstitial cell-stimulating hormone is not available.

‡There exists no satisfactory method for determining quantitatively the changes in the number of interstitial cells or in the amount of interstitial tissue. Intricate methods have been devised and abondoned (Sand and Okkels, 1936).

§Recent histochemical evidence supports this view (Pollock, 1942).

‖Sparrows, normally having no Leydig cells in their testes, exhibit typical Leydig cells after injections of equine gonadotropin (Pfeiffer and Kirschbaum, 1943).

Preceding descent of the testes, experimentally induced, Engle (1932b) reported a significant growth of the scrotum and an increased testicular mobility; it seems reasonable to believe that part of this mobility was due to growth of the ductus deferens. In prepuberal and hypophysectomized ground squirrels under the experimental influence of gonadotropic hormones, the scrotum acquires the size and anatomical features characteristically occurring in breeding males and the ductus deferens increases remarkably in length (Wells, unpublished observations).

Summary: Descent of the testis has been induced by administering the following gonadotropic agents: fresh hypophysis tissue, aqueous hypophyseal extract, urine of pregnant women, extracts of pregnancy urine, blood serum from pregnant mares, extracts of pregnant mare serum, and extracts of urine from normal men. The gonadotropins cause the testes to grow and to secrete androgen, the latter hormone causing growth of the scrotum and the ductus deferens.

3. *The Effects of Injecting Androgens.—*

Descent of the testis: In the following, the testes have been observed to descend in response to injections: patients exhibiting cryptorchidism (Hamilton and Hubert, 1938; McCullagh and McGurl, 1939),* monkeys (Hamilton, 1938), rats (Steinach and Kun, 1940), and ground squirrels (Wells, 1935a, 1942a; Wells and Overholser, 1939; Wells and Moore, 1936).

Growth of the testis: While there is abundant evidence that injections of androgen suppress the hypophysis and thereby injure the testis (Moore and Price, 1932; Moore, 1941), it is also clear that under certain circumstances androgen stimulates the testis, although the route by which it exerts its stimulating action is questionable (Wells, 1942a; Moore and Morgan, 1942). As discussed previously in considerable detail (Wells and Moore, 1936), the testes of different species exhibit different responses to androgen.

These differences are illustrated vividly by the effects of androgen on testicular growth. Thus, in intact prepuberal ground squirrels, a fourfold increase in the weight of the testes can be secured; in most respects, these testes resemble those of rutting adults. Conversely, the testes of immature injected rats usually are smaller than those of untreated littermates.

There is little information concerning the effect of androgen on the size of the human testis. Testicular enlargement has been reported by Webster (1938).

Testicular growth, when it occurs, is due mostly to hypertrophy of the seminiferous tubules. It is not due to the interstitial tissue because, as generally agreed, the interstitial cells are not stimulated

*As a therapeutic measure for cryptorchidism, androgen seems to be effective in only a small percentage of patients (Thompson and Heckel, 1939b; Hamilton, 1941).

by androgen (Cutuly, McCullagh and Cutuly, 1937; Greep, 1939; Selye and Friedman, 1941; Shay, Gershon-Cohen, Paschkis and Fels, 1941; Moore and Morgan, 1942; Wells, 1942a, 1942b, 1943).

Seminiferous tubules: Our knowledge about the response of human tubules to androgen has been secured indirectly by observing the semen of patients. I know of only two papers which report an increased number of spermatozoa in response to androgen (Vest and Howard, 1938; Rubenstein and Kurland, 1939). At least six other clinical papers report decreased numbers of spermatozoa (for this literature, see Pullen and associates, 1942b). Obviously it is desirable to study this question by observing the tubules secured at biopsies; this method of investigation is being used (Charny and Meranze, 1942).

There are numerous investigations concerning the action of androgen on the seminiferous tubules of animals. These investigations have been reviewed recently by Moore and Morgan (1942) who state that "the effects of androgens upon the testis remain an open question." In several species, an inhibition of the tubules has been observed; but in one species and in other species especially after hypophysectomy, stimulation of the tubules has been noted. The precocious formation of spermatozoa has been induced by androgen only in the ground squirrel (Wells, 1935a, 1942a; Wells and Moore, 1936; Wells and Gomez, 1937b; Wells and Overholser, 1939). But the production of spermatozoa after puberty has been obtained by injecting hypophysectomized rats with androgen (Cutuly, 1941a; Nelson, 1941).

The inguinal bursa: In at least two species of rodents, the size of this paired structure depends upon androgenic stimulation and upon mechanical distention by the testis (Wells, 1937b; Wells and Overholser, 1937).* The original evidence for this statement was secured by observing the bursae of animals which had been unilaterally or bilaterally castrated. Additional observations have been made; in animals receiving androgen, the bursae exhibit significant growth (Wells, unpublished data). In monkeys, Hamilton (1938) has reported that injections of androgen cause the cremaster muscle to grow.

Scrotum: It is generally agreed that during the postnatal period the scrotum grows in response to injections of androgen. Such growth has been observed in monkeys (Hamilton, 1938). The scrotum became bilobed, dependent, and rugose, while the scrotal raphe became red and prominent. After injections, the scrota of rats increase in size (Hamilton, 1936; Martins, 1938). In the ground squirrel, unpublished observations show that injections of androgen cause the scrotum to grow and become pendulous, to acquire a black color, and to exhibit coarser and less abundant hair.

In the rat, scrotal growth is due to androgenic stimulation and to the distending action of the testes (Selye, 1943). In this species,

*Owing to the fact that in 1937 we were not familiar with the paper by Klaatsch (1890), we referred to the inguinal bursae as the "fibro-muscular scrotal sacs."

scrotal contractility is regulated by androgen (Andrews, 1940; Tyrrell, Andrews and Zelle, 1942).

The human scrotum is stimulated by androgenic treatments (Hamilton and Hubert, 1938; Vest and Howard, 1938; Webster, 1938).

Ductus deferens: This organ also is governed by a male hormone (Vatna, 1930). Several investigators have stated that injections of androgen cause the ductus to become longer. I have some unpublished data showing that in rodents androgen may cause almost a twofold increase in the length of the ductus, average lengths being the following: in seven controls, 28.5 mm. and in twenty-one injected animals, 47.2 mm.

4. *Effects of Injecting Estrogen:* Greene, Burrill, and Ivy (1940) have obtained intersexual rats by injecting their mothers during pregnancy. Among the intersexes, representing modified males, they observed the failure of testicular descent and the absence of scrota. At birth, the testis exhibited an atypical position near the inferior pole of the kidney.

In male mice, injections of estrogen cause the testes not to descend (Burrows, 1936). In adult rodents receiving estrogen, scrotal testes return to an abdominal position (Wells, 1935a).

PRESENT STATUS OF THE PROBLEM

The question immediately arises as to what causes the gubernaculum to evert the abdominal wall, thus producing the inguinal bursa. The size of the gubernaculum in fetal freemartins (Bissonnette, 1924) suggests that androgen may be the stimulating agent; apparently there is no literature concerning the effect of hormones on the gubernaculum.* I am investigating this problem (Wells, unpublished data).

Two stages of descent should be recognized. The first involves the passage of the testes into the inguinal bursae. During the second stage, bursae and testes extend downward and enter the scrotum.

Both stages occur prenatally in such forms as man, monkeys, and domesticated ungulates (horses, cattle, pigs, sheep, and goats†), and postnatally in the opossum (which has a "prepenial" scrotum). Several species, illustrated by rodents, exhibit the second stage during the puberal period. In such species, there is inadequate information concerning the time when the first stage occurs. I have found that in newborn mice, rats, rabbits, and guinea pigs, the bursae of preserved specimens usually contain the caudal epididymides and sometimes the inferior extremities of the testes (unpublished observations).

Since most of the recent observations concern postnatal rather than prenatal descent, the former will receive first attention.

*One paper (Abrahamson, 1942) deals with a response of the "gubernaculum" to hormones. From the illustrations in the paper, it seems that the author was mistaken in his identification of the gubernaculum.

†Personal communication from Dr. W. L. Boyd, Department of Animal Husbandry, University of Minnesota.

Puberal descent: During puberal descent, it is probable that the gubernaculum functions chiefly, as its name implies (governor), as a guiding agent for the testis. But there is experimental evidence that this structure is not absolutely necessary; in a small percentage of rodents in which the gubernaculum was severed unilaterally during the prepuberal period, the testes subsequently descended into the scrotum (unpublished data). At autopsy, such testes lacked adhesions. In weight and in quantities of spermatozoa, these resembled contralateral, normal testes.

Hypophyseal gonadotropins provide stimuli essential for descent of the testis since the testes of prepuberally hypophysectomized animals, after failing to descend at the expected time, can be induced to descend by making intermuscular implants of hypophyseal tissue or by injecting gonadotropic hormones. The ground squirrel affords additional information which supports this thesis; in this species after annual rut, the testes normally return from the scrotum to the abdomen. The information was secured by assaying the quantities of gonadotropic hormones in the hypophyses of different animals. The quantities were found to be minimal in animals with abdominal testes (prepuberal or adult), greater in those with partially descended testes and still greater in those with scrotal testes (Wells, 1938). It may be mentioned that low environmental temperature favors high levels of gonadotropins in the ground squirrel with the striking consequence that, through the experimental provision of a cold environment, the testes may be caused to remain in the scrotum for more than twelve months (Wells and Zalesky, 1940). In this species, descent normally occurs during the period of hibernation.

Greater responsiveness of the testes to gonadotropins is a characteristic of puberty. The testes respond to hypophyseal gonadotropins by growing and by producing androgen.*

Testicular growth is undoubtedly related to descent. It causes ponderal enlargement of the inguinal bursae; the evidence for this is that in unilateral castrates, the weight of the bursa is less on the operated side (Wells, 1937b; Wells and Overholser, 1937). Obviously, the bursae must enlarge in order to reach the scrotum. However, there are two reasons for believing that testicular growth is not a major factor in descent. First, human testes descend before the onset of puberal testicular growth. Second, if a paraffin pellet is placed inside the tunica albuginea, after removing the contents of the latter, injections of androgen cause the pellet to descend (Martins, 1938); the pellet simulates a testis but differs from one by being unable to grow.

The chief hormonal factor in descent probably is the growth-stimulating action of androgen on accessory reproductive organs (in-

*They also exhibit a gametogenic response which results, after they reach the scrotum, in the production of spermatozoa.

guinal bursa, including cremasteric muscle; ductus deferens; scrotum) and their associated structures (spermatic vessels). Near the time of puberty, these organs probably have acquired a greater capacity to respond to androgen. Concerning this, we have presumptive evidence; the evidence is that as rats become older, their seminal vesicles respond more readily to certain androgens (Hooker, 1942; Selye and Albert, 1942).* From the available data (limited to one species, namely, the bull), it seems that the puberal increment of testicular androgen is gradual rather than rapid (Hooker, 1937).

Some of the androgen may be derived from extragonadal sources such as the juvenile adrenal cortex. In some species (rodents) the evidence for this is convincing (Price, 1936, 1939, 1941, 1942; Davidson and Moon, 1936; Howard, 1937, 1938, 1939; Burrill and Greene, 1939, 1940; Wintersteiner, 1941).

Spontaneous, puberal descent of the human ("undescended") testis deserves careful study.† Desirable observations are those on the patient exhibiting unilateral cryptorchidism because they may assist in answering the following questions: (1) How can prenatal hormones, equally distributed to both sides of the body, exert unequal influences on the two testes? (2) Why, in the case of one and the same testis, should antenatal hormones be ineffective and puberal hormones effective?

Prenatal descent: Hormones probably are involved. This view receives support from the following observations: (1) in several species, postnatal descent has been induced by injecting hormones, (2) the hormones in question are present during pregnancy, (3) after parturition, the testes of rhesus monkeys ascend from the scrotum (Wislocki, 1933).

The involvement of chorionic gonadotropin has been postulated (Engle, 1932b). If this hormone is a factor, it would be expected to exert its action by stimulating the testis. But the fetal testis may not be able to respond; in pouch-young opossums the reproductive organs of which exhibit fetal characteristics, the testis fails to respond (until 63 to 70 days after birth) to injections of gonadotropin (Moore, 1940; Moore and Morgan, 1943). Furthermore, as a manifestation of testicular stimulation by the hormone, one would expect conspicuously rapid growth of the testis. The available data for man (Table I) fail to reveal exceedingly rapid growth during the critical period under discussion (previous to the seventh lunar month) and, as pointed out earlier, they also fail to indicate that the testis regresses in size immediately after birth (i.e., when chorionic gonadotropin is no longer available). If the hormone does not stimulate the fetal testis, could it influence descent by stimulating some fetal organ other than the

*Similarly, with ascending age during the interval between birth and puberty, certain female reproductive organs become more responsive to estrogen. Recent literature on this subject is available in a paper by Wilson and Young (1941).

†Apparently "migratory" testes are the ones which "descend" at puberty (Thompson and Heckel, 1939a).

testis? At present it is impossible to answer the question, but one is tempted to speculate that this hormone might cause the production of androgen by the provisional cortex ("fetal cortex") of the suprarenal gland. In such speculation the main considerations are the following: (1) injections of equine gonadotropin stimulate the suprarenal cortex of hypophysectomized rodents (Zalesky, Wells, Overholser and Gomez;* (2) in juvenile rodents, the suprarenal gland probably secretes androgen; (3) postnatal descent of the testis can be induced by injecting androgen. Finally, in order for chorionic gonadotropin to be a factor in descent, an adequate quantity would have to be present just preceding or during descent. Actually, the quantity of this hormone is greatly diminished during the last two trimesters of pregnancy (Evans, Kohls, and Wonder, 1937).

In view of what has been said concerning the relation of androgen to puberal descent, is it likely that androgen influences prenatal descent? If so, androgen must be available during pregnancy and the fetal organs must depend upon it during their normal development. The secretion of androgen by the fetal testis has been postulated by Lillie (1917). This hormone has been extracted from fetal testes (Womack and Koch, 1932; Hooker, 1937), but this does not prove necessarily that it originated in them. That androgen is present in pregnant animals (rat) has been reported by Burrill and Greene (1942). If one assumes that androgenic hormones influence descent, progesterone needs to be considered in this problem because it has been found to have androgenic properties (Lamar, 1937, 1940; Greene, Burrill and Thompson, 1940). The possible production of androgenic hormones by the fetal adrenal glands should not be overlooked. However, in the fetus, there is no evidence indicating that accessory reproductive organs (inguinal bursa, ductus deferens, and scrotum) depend upon androgen. The prostates of pouch-young opossums, exemplifying accessory reproductive organs, continue their normal development for several weeks after castration (Moore, 1941b). Further study is desirable.

Concerning estrogen, Wislocki (1933) postulated that this hormone might promote descent by acting upon the scrotum; yet subsequent observations by other investigators make this appear to be very unlikely.

We may now consider certain nonhormonal factors. Moszkowicz (1934) calls attention to an embryological phenomenon which makes descent a possibility but which sheds no light on the forces of descent. He suggests that in males the regression of the Müllerian ducts favors descent by providing greater testicular mobility, and that retention of them frequently causes cryptorchidism; in three human subjects,

*However, the corticotropic factor in mare serum, unlike the gonadotropic, is said not to be destroyed by heating (Golla and Reiss, 1942).

he observed the simultaneous occurrence of hermaphroditism (including the presence of the "broad ligament") and cryptorchidism. But cryptorchidism is not always associated with hermaphroditism. Indeed, in the most extreme case of hermaphroditism recorded among mammals (Wells, 1937a), the mesometrium (infraprimate homologue of the broad ligament) failed to prevent the experimental induction of descent by injections of chorionic gonadotropin; it is of general interest that in response to these injections, the ovotestes of one and the same animal produced ova, corpora lutea, and spermatozoa.

The (theoretical) contraction of skeletal muscle in the inguinal cone has limited application. This is because the cone, although a prominent structure in rodents, is not well developed in human fetuses.

It becomes increasingly evident that the gubernaculum does not pull the testis into the scrotum. It may be recalled that Forssner (1928) vehemently denies the presence of smooth muscle in the gubernaculum. The view that retrogressive shrinkage of the gubernaculum pulls the testis downward is open to a serious criticism—the gubernaculum is not attached distally to an immovable structure.

CONCLUSIONS

1. Some observations suggest that in man hormones (chorionic gonadotropin and androgenic substances) are related to normal, prenatal descent of the testis. However, the capacity of fetal organs to respond to available hormones deserves additional investigation.

2. In certain species, hypophyseal gonadotropins and androgen influence normal, puberal descent.

3. It appears that estrogen does not favor normal descent.

4. If, in man, "unilaterally undescended testes" descend spontaneously several years after birth, the question arises as to how hormones (equally distributed to both sides of the body) could influence the prenatal descent of one testis and not of the other.

5. It is unlikely that the gubernaculum pulls the testis into the scrotum.

6. It is questionable whether the gubernaculum penetrates the external spermatic fascia and attaches to the scrotum.

7. The inguinal cone probably has little or no influence upon descent of the human testis.

8. Factors causing the formation of the inguinal bursae (Klaatsch) are unknown.

ADDENDUM.—After submitting the manuscript for publication, N. R. Wyndham's article concerning the morphologic aspects of descent has been published (J. Anat. 77: 179-188, 1943). There is presented a series of twenty-three gubernacular measurements. From observations in preparations stained with hematoxylin and eosin, it is reported that the gubernaculum contains striated and unstriated muscle fibers. In specimens measuring 6 to 12 cm. (crown-rump), it is said that the gubernaculum could be traced to the scrotum. Yet Wyndham does not refute directly the statement of other investigators that in the newborn infant the

gubernaculum lies exclusively within the inguinal bursa (as illustrated in R. H. Hunter's Fig. 65; Brit. J. Surg. **14**: 125-130, 1926).

Concerning hormonal phases of the problem, newborn infants exhibiting female pseudohermaphroditism are of interest. This is because of the evidence which they may furnish as to whether human fetal organs can respond to androgenic hormones (regardless of their source) and whether in man the fetal cortex of the adrenal produces such hormones. A recent discussion of these questions is available in an article by T. E. Bratrud ("Congenital Hyperplasia of the Adrenals," Thesis, University of Minnesota Library, May, 1943).

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Review of Recent Meetings

REPORT OF THE ANNUAL MEETING OF THE AMERICAN SURGICAL ASSOCIATION, MAY 13 AND 14, 1943, CINCINNATI, OHIO

J. DEWEY BISGARD, M.D., OMAHA, NEB.

PRESIDENTIAL address, Vernon C. David, Chicago.—From a historical review of the influence of wars on medical education there was evolved a discussion of the influences of the current war and the problems imposed by it upon medical education, both present and future. The accelerated program, the reduction of faculty personnel, and the curtailment of postgraduate training and of research is likely to result in some qualitative reducation of medical education.

It is imparative to formulate a comprehensive plan to provide postgraduate training for those who entered the service before completion of such training.

Closer cooperation and more overlapping of the clinical and fundamental departments in medical education should be encouraged. The present high standard of qualification for a degree in medicine and especially for certification by specialty boards should be maintained.

Experimental and Clinical Studies on the Effects of Pedicle Grafts of Jejunum in the Wall of the Stomach on Gastric Secretion, William DeW. Andrus, Jere W. Lord, Jr. (by invitation), and **Paul Stefko,** New York.—In animals, small (4 by 6 cm.) segments of jejunum with circulation intact implanted in the wall of the stomach caused a reversal of the normal reaction to histamine as reflected both in the gastric analysis and in direct measurements of the pH of the gastric mucosa. This inhibitory effect was also evident when alcohol was used as the secretory stimulus. A study of the effects of grafts from different portions of the intestinal tract indicated that the substance responsible was confined to the jejunum and duodenum where it could be demonstrated in washings of isolated loops.

Such grafts were efficacious in preventing and curing experimental ulcers in animals.

This operation has been done in four refractory cases of peptic ulcer with alterations of gastric secretions as in the animals and with symptomatic relief in three.

Gastric and Duodenal Ulcers in the Naval Personnel, Waltman Walters, Captain, M.C., U.S.N.R., and **Hugh R. Butt** (by invitation), Lieutenant, M.C., U.S.N.R.—**Medical management for patients with ulcer on active duty aboard ship is difficult and frequently impossible.**

Hypersecretion and hyperperistalsis are a part of seasickness, hence Naval personnel with chronic duodenal ulcers who desire to remain in the service are best operated upon, the operation of choice being partial gastrectomy. Ninety per cent of patients with peptic ulcers have had these ulcers before entering the service and 50 per cent of these become invalided in the service. The interesting problem arises, can a man be returned to active duty after a resection of the stomach.

In a series of thirteen cases in which gastric resection was done, eleven of the patients have been returned to active duty and all are getting along without symptoms. Eighty-five per cent of the operations performed for peptic ulcer in the naval service have been resections of the Polya type.

In the discussion **L. R. Dragstedt,** Chicago, stated that most experimental and clinical evidence indicated that hyperacidity is the principal cause of ulcer and that some hormone as histamine may be the exciting factor. He referred to his experiments in which ulcers developed in pedicle grafts of jejunum in the wall of the stomach of dogs and was unable to rationalize his results with those reported just previously. **J. S. Horsley,** Richmond, Va., saw little cause for difference in the physiologic response to the pedical graft of jejunum and the established gastrojejunostomy.

Physiological Problems in Surgery of the Pancreas, Lester R. Dragstedt, Chicago.—It is probable that both man and the lower animals may survive and maintain a good nutritive state following total duodenectomy provided the free flow of pancreatic juice and bile into the upper intestine is not prevented. Complete removal of the pancreas produces a permanent impairment but one which can be fairly adequately controlled with insulin and lipocaic. The necessity for insulin and lipocaic following ligation of the pancreatic ducts depends upon the degree to which the atrophy of the pancreas affects the islet tissue. The digestive disturbance produced by the absence of pancreatic juice from the intestine can be only partially corrected by replacement therapy.

Depancreatized dogs survive for long periods of time with insulin only if supplemented by feedings of pancreatic tissue. Fifty per cent of the dogs in which the pancreatic ducts have been ligated develop fatty livers, probably from the deficiency of lipocaic. There is evidence that lipocaic is a hormone derived from the alpha cells of the islets.

A. O. Whipple, New York, during the discussion, stressed the desirability of preserving the external secretion of the pancreas in delivering the secretions into the proximal small bowel. This he has accomplished in his last seven cases of pancreatoduodenectomy. In two cases the pancreatic fistula was subsequently transplanted to the jejunum and in three the exposed pancreatic duct in the cut surface of the pancreas was anastomosed to the side of the jejunum. Some patients deprived of pancreatic juice show reduction of fat tolerance.

In two cases, eighteen months and three years after resection of the duodenum and partial resection of the pancreas with ligation of the pancreatic duct, the liver showed no abnormal deposition of fat.

A. Brunschwig, Chicago, reported one case in which almost the entire pancreas was removed with a benign tumor and no diabetes developed. Necropsy examination of two cases five and five and one-half months after pancreatoduodenectomy with ligation of the pancreatic duct showed survival of much of the acinous tissue as well as islet tissue.

R. B. Cattell, Boston, reported seven cases of resection in which the pancreatic duct was anastomosed to the jejunum with a necrosing suture as used by Coffee in ureterocolic anastomosis.

The Recognition and Management of Acute Trauma to the Pancreas With Particular Reference to the Use of the Serum Amylase Test, Howard A. Naffziger, and **H. J. McCorkle** (by invitation), San Francisco.—When the abdomen is injured, occasionally the pancreas may be wounded. Injury to the pancreas also may occur during operations on the stomach, duodenum, pancreas, or spleen. The use of the serum amylase test in such cases has made possible a more accurate diagnosis of pancreatic injury. Serial determinations of the serum amylase also

give some indication that the enzyme is continuing to leak from the wounded pancreas. This test for serum amylase has been useful in the recognition and in the management of acute injuries to the pancreas.

Studies in seven cases of traumatic injury of the pancreas were reported showing the early rise in serum amylase. In two cases of partial resection of the pancreas there was also early rise and a prompt fall with cessation of fistulous drainage.

Skin Removal in the Radical Breast Amputation, J. Stewart Rodman, Philadelphia.—Recent papers from large clinics admit 25 per cent or more local or skin recurrences. It is believed that such a high percentage of local recurrences are unnecessary and indicate insufficient skin removal.

Reported were 132 personal cases in which the Rodman operation was used; there were 61 per cent of five-year cures. Only 2.2 per cent developed local recurrences. Primary closure of the wound without skin grafting was possible in all cases.

In the discussion, **D. Guthrie,** Sayre, Pa., stated that local recurrences in the skin occurred often without remote matastases and for this reason should be excised.

S. Harrington, Rochester, Minn., stated that the type of incision should depend upon the location of the tumor in the breast. A tumor in the superior lateral quadrant is adequately skirted by a very different incision than one in the upper mesial quadrant. **G. J. Heuer,** New York, presented evidence in support of the wide excision of skin in the Halsted operation and the use of grafts to close defects when necessary. **W. C. White,** New York, stated that the frequency of local recurrences depends upon the type of cases included in one's report. Local recurrences are much more frequent in advanced cases encountered in charity institutions than in earlier cases as seen in private practice.

Amputations in War, Norman T. Kirk, Brigadier General, M.C., U. S. Army.—The guillotine or flapless type amputation is the amputation of choice, the simplest, quickest, and easiest method of amputation on a badly shocked or critically ill patient, for the removal of a hopelessly destroyed extremity and as a life-saving measure when amputation is indicated in the presence of infection such as gas gangrene, a septic joint, or an uncontrolled osteomyelitis.

Skin traction following amputation either by the use of zinc oxide adhesive plaster or stockinet with Ace Adherent is essential after surgery. Healing, if infection has not been too severe in this type stump, will be almost complete at the end of six weeks.

Primary closure of war wounds is a dangerous procedure. Experience in World War II has shown that where primary suture of wounds is attempted or where wounds are tightly packed, they soon became grossly infected.

A guillotine amputation is a two-stage amputation. The repair of the guillotine stump may be classified as a plastic closure, plastic resection when bone shortening is necessary, or reamputation when the stump is too long or too short.

Surgical Principles Opposed to Rule-of-Thumb in the Treatment of Compound Fractures, Clay Ray Murray, New York.—There is a great deal of investigative work being carried out at the present time on the treatment of compound fractures. Many of the conclusions voiced are obtained by punch-card analyses of the effects of single factors in the treatment of the case groups. This is productive of actuarial statistics which may determine accurately the percentage chance a patient has under the routine use of a given procedure, but which run the risk of being of doubtful value as criteria for the treatment of any individual case. Moreover, their adoption as a basis for a routine procedure may lead to violation of known and accepted surgical principles in the individual case.

The soft tissue wound and fracture should be considered as parts of the same problem and every effort made to prevent infection and the damage resulting from infection. This is accomplished by removal of as much contamination of the wound as possible, removal of dead and devitalized tissue, obliteration of dead spaces, the closure of the wound without tension, and rest of the part. In addition, the fracture must be reduced and maintained in reduction. Since there is no evidence that sulfonamide drugs cause harm in the wound and since there is evidence that they may limit if not prevent infection it is advisable to use them.

F. L. Meleney, New York, in the discussion, stated that an evaluation of methods of treating wounds and compound fractures could be attained only by analyzing a large group of cases under controlled conditions, and that some standardization of treatment is necessary in a military surgery.

The Medical Treatment of Acute Infectious Osteomyelitis, D. E. Robertson, Toronto.—Twenty-five cases of acute infectious osteomyelitis in children treated by sulfonamides and without the assistance of either splinting or surgical operation during the acute phase were compared with those treated by sulfonamides plus early operation upon the lesion or abscess produced by the lesion.

The results obtained in patients treated by sulfonamides without early operation are very much better than those treated by other means.

In the former group there was a mortality of 4 per cent as compared to a mortality of 20 per cent in those treated before the advent of the sulfonamides. These children were given 8 to 10 Gm. of sulfathiazole daily.

The fact that the disease in the first instance arises from an infection of a superficial tissue and becomes a septicemia and later again becomes a bone lesion, makes it rational to attack it early with a bacteriostatic drug that will prevent its wide dissemination via the blood stream, and its local invasion to form local lesions in bone. During the administration of sulfonamides it can be demonstrated that the individual's protective reaction to the organism and its toxin is not interfered with but carries on with increasing power in response to the antigen of the toxin.

Some of the bone abscesses and subperiosteal abscesses disappeared spontaneously. Others were aspirated, and some left alone discharged spontaneously. It is felt that the pathologic appearance of the involved bone had changed, that sequestra were rarely formed, involucrum was much smaller in extent, and that destruction of bone was much limited.

K. Speed, Chicago, in the discussion, agreed that operative interference should be delayed and the reliance placed in the sulfonamide drugs during the acute stage. He felt that there was an opportune time for the institution of drainage. Penicillin may prove even more effective than the sulfonamide drugs.

J. A. Key, St. Louis, expressed the belief that early drainage was often necessary and desirable in conjunction with the sulfonamide therapy. **D. E. Robertson,** Toronto, in closing, stated that he was now using sulfadiazine in these cases.

Peroxide Ointments, Mont R. Reid, and **William A. Altemeier** (by invitation), Cincinnati.—The value of peroxide therapy in certain types of infections is well established, but previous methods of application were not entirely satisfactory. Various peroxides can be incorporated in a carbo-wax guaiacol base and applied to the wounds as an ointment very satisfactorily. These ointments have been prepared by the authors with the aid of Merrill and Company.

Zinc peroxide has proved the best one to incorporate in an ointment for most purposes. It liberates oxygen in contact with a wound over a period of five or more days, as a single dressing. Urea peroxide liberates oxygen rapidly and is more irritating, but is very effective in early treatment of Lewisite burns.

In the discussion, **F. L. Meleney,** New York, stated that he had developed a similar ointment of zinc peroxide and had found it stable and satisfactory. He

emphasized the necessity of removing necrotic tissue to permit intimate contact of the peroxide to the tissues.

The Parenteral Administration of Fluids During the Operation and the Immediate Postoperative Period in the Light of Additional Knowledge of the Effects of Surgical Anesthesia (Ether, Cyclopropane, and Avertin), Upon Renal Function in Man, Frederick A. Coller, Carl A. Moyer (by invitation), **Kenneth N. Campbell** (by invitation), and **Vincent L. Rees** (by invitation), Ann Arbor, Mich.—With ether anesthesia renal blood flow increases or remains relatively unchanged provided that blood pressure does not fall significantly either as a result of blood loss or deep anesthesia.

The rate of glomerular filtration (inulin clearance) decreases under ether anesthesia excepting when renal blood flow is increased.

Cyclopropane anesthesia is attended by a significant decrease in the rate of glomerular filtration although renal blood flow and blood pressure may be greatly increased. The association of a loss of blood sufficient to induce a fall in blood pressure with cyclopropane anesthesia may be associated with "total renal failure."

The duration of the renal impairment as indicated by the decreased glomerular filtration rate and total urinary volume varies from a few hours to a week; it seems to depend somewhat upon the relative amount of blood lost and in patients losing little blood, upon the severity of the blood pressure fall.

Therefore, the maintenance of extracellular fluid volume and acid-base equilibrium during the operative and immediate postoperative period cannot be safely effected with the simple repair solutions, or saline or Ringer's solution, because their physiologic effectiveness depends upon selective excretion by the kidney of the excess chloride ion.

The parenteral administration of these fluids even in relatively small amounts during the period of renal impairment has been found to induce a fulminating and even fatal acidosis in some individuals.

During the discussion, **F. A. Coller,** Ann Arbor, Mich., reported two patients who developed oliguria and chloride intoxication with retention of water and marked distention and prostration with an impending fatal outcome as a result of the excessive administration of sodium chloride following operation. These were cured by the administration of sodium lactate, withholding the fluids, and in one case an ileostomy. He recommends that no sodium chloride be given in the fluids for the first two days following operation unless there has been an appreciable loss of chlorides in vomitus, aspirated stomach content, or other means. The retention of chlorides resulting from failure of filtration through the kidney following anesthesia in operations may result in a dangerous chloride intoxication.

A. Blalock, Baltimore, in the discussion, stated that this was a timely warning because there was a dangerous prevailing idea that salt solution could be administered with impunity.

Pilonidal Cysts and Sinuses, John C. Burch, Lt. Col., M.C., U. S. A., **Max Levine,** Major, S.N.C. (by invitation), **Thomas E. Smith,** Captain, M.C. (by invitation), and **Frank C. Shute, Jr.,** Captain, M.C.—Since Jan. 1, 1942, there have been 114 cases of pilonidal cysts in the Brooke General Hospital. Eighty-five per cent of the patients are completely healed and on duty. In cases of pilonidal cysts and sinuses the problem of treatment has revolved around the question of closing the wound to obtain primary healing or leaving it open to granulate in. Of fifty-nine cases in which the wounds were closed, forty-eight were healed in eight days and remained healed without recurrence. Eleven were completely healed in twenty-four days. This was accomplished by preoperative treatment for the sterilization of the sinus in so far as possible, attention to adequate sharp dissection, meticulous hemostasis, and the use of nonabsorbable sutures and postoperative pressure

dressings. In many of these cases the dead space was obliterated by an operative technique described by the author. This involved an incision through the gluteal fascia and muscle lateral to the sacrum, approximation of the mesial edges of each side rolling the flaps in over the sacrum and coccyx, and the approximation of the lateral flaps to each other in the midline. The skin was approximated over this.

In the discussion, **H. B. Stone,** Baltimore, emphasized the essential principals of cleaning up the infection preoperatively, of complete removal of the sinus, of closing the wound to obliterate the dead space and without tension.

H. F. Graham, Brooklyn, suggested that the sinus be sterilized by electrocoagulation as a first step in excision. **J. M. Mason,** Birmingham, stressed the point that such cases were seen infrequently in civilian practice.

Prevention of Infection in Accidental Wounds and Burns, Frank L. Meleney, New York.—Under the auspices of the national research council there has been carried out during the past year an extensive study on the prophylaxis of wound infection, in civilian accidental wounds, compound fractures, and burns. These observations have been made in nine different medical centers in this country.

The bacteriologic aspects of the problem were carefully considered, including the primary and secondary contamination. The course of the wound healing was carefully observed. The data from the records were transferred to punch cards and statistically analyzed. Various forms of treatment have been used in order to determine, if possible, the role of the newer chemotherapeutic agents in the prevention and treatment of infection and the role of other factors.

There were collected 682 cases with major injuries of the soft tissues, 471 compound fractures, and 347 burns. There was a slightly larger number of infections in cases in which the wounds were irrigated with salt solution and in those which were debrided. Also there was a slightly less incidence of infection in the compound fractures which were closed.

The mortality from infection in these cases was extremely low. While the sulfonamides as they were used in this series almost certainly minimized septicemia and the generalized spread of infection, they did not lower the incidence of local infections.

There was a slightly higher incidence of infection in those cases in which the sulfonamide drugs were used in the wounds. In burns the best results were obtained from the use of vaseline gauze and pressure dressings. The addition of sulfonamide drugs administered by mouth and by topical application caused a slight reduction in the incidence of infection.

E. Graham, St. Louis, discussed this project of the National Research Council stating that the precipitation of war at Pearl Harbor and observations made in respect to the use of sulfonamide drugs in the wounds following this attack augmented and accelerated the project.

J. S. Lockwood, Philadelphia, stated that the use of the sulfonamide drugs was justified upon the evidence that they prevented widespread infection and lowered mortality, irrespective of evidence of failure to minimize local infection. He spoke of the favorable early reports upon the use of penicillin.

J. A. Key, St. Louis, believed that this study did not give a true picture of the bacteriostatic value of the sulfonamide drugs. His clinical observations had given a much more favorable picture.

An Experimental Study on the Use of Serum, Plasma and Amino-Acids in the Replacement Therapy of Fatal Shock Due to Repeated Hemorrhage, Robert Elman, and **Carl E. Lischer** (by invitation), St. Louis.—Fatal surgical shock was produced experimentally by rapidly bleeding 10 c.c. per kilogram every hour in the

unanesthetized dog. Death occurred after an average of about 40 c.c. per kilogram had been removed. The removed amount of blood in a single bleeding was less often fatal.

Immediate replacement of the volume of lost blood by a 10 per cent solution of glucose did not alter the results. However, if the solution contained 5 per cent of glucose and 5 per cent of the amino-acids of hydrolyzed casein or beef serum, the amount of blood which could be removed before death was increased to an average of 55 c.c. and the survival time was prolonged by 40 per cent. A comparative study of the effect of immediate replacement with pure amino-acid solutions, serum, citrated plasma, and heparinized plasma, proved that the first three were no better than the hydrolyzate. The heparinized plasma was the best of all, permitting removal of an average of 67 c.c. per kilogram before death and an increase in the survival time of 60 per cent.

Microscopic observations of biopsy specimens of the liver indicated that the beneficial effect of the injections of hydrolyzed protein were probably due to the replenishment of hepatic protein, thus enabling the animal to withstand further loss of blood more effectively.

There is much evidence that the citrate used in citrated plasma has a very toxic and deleterious effect; this explains the superior results obtained from heparinized plasma.

In the discussion, **L. R. Dragstedt,** Chicago, questioned the statement that amino acids merely replace tissue proteins and that they could be converted to plasma. **C. C. Lund,** Boston, stressed the desirability of a substitute for plasma in situations in which sufficient plasma is not available or in which the cost makes its adequate use almost prohibitive.

The Role of the Nervous System in the Production of Shock, Dallas B. Phemister, Chicago.—To lower the blood pressure to shock levels by as purely a neurogenic mechanism as possible, the cardio-aortic nerves of the rabbit and the carotid sinus nerves of the dog were stimulated electrically under anesthesia. Maintenance of the blood pressure at or below the threshold shock level of 70 mm. of mercury by continuous stimulation resulted in death of the animals in six to nine hours in a state of shock during the terminal period. In control experiments with only the nerve stimulus deleted, the animals lived up to twenty hours in the case of rabbits and to thirty-five hours in the case of dogs. However, it was possible by continuous stimulation to maintain blood pressure at low shock levels for three to five hours with remarkably little impairment of the circulation. Release of the stimulus in the course of this period was followed promptly by restoration of pressure to the initial level, bleeding was also well tolerated, and blood changes were very slight.

When the animal was first bled repeatedly until an impending or actual state of shock was reached, stimulation started then would cause a further drop in blood pressure and continuation of it would hasten death. However, loss of quantities of blood up to 15 per cent of the total blood volume made little difference.

Exposure of somatic nerves and stimulation by cutting, pinching, or stretching as might occur in accidental and war wounds, or stimulation by an electric current, yielded varying results on blood pressure, from a slight rise to a slight fall under varying experimental conditions. However, under no circumstances was a marked and prolonged fall in blood pressure produced in any way simulating shock.

Aseptic section of the spinal cord of the dog at the seventh cervical vertebra under evipal anesthesia lasting about three-fourths of an hour interrupted all vasomotor impulses from higher centers and lowered blood pressure to 70 mm. or below, where it remained for two to four days without the appearance of the picture of severe traumatic shock. Subsequently, the blood pressure gradually rose.

The results of these experiments indicate that in the absence of blood and plasma loss, the blood pressure may be lowered to shock levels for many hours by reflex nervous inhibition before a state of shock is created. Such lowering could be produced only by stimulation of special depressor nerves, and somatic nerves involved in ordinary wounds did not in consequence convey afferent impulses which resulted in marked and prolonged lowering of blood pressure. Psychic influences created by pain and disturbing special sense impulses occasioned by a wound may cause reflex lowering of blood pressure and syncopy; when these are superimposed on shock produced by blood or plasma loss, it may be thereby aggravated. Primary shock produced exclusively through the nervous system would appear to be a very improbable occurrence.

A Study of Traumatic Shock by the Use of Radioactive Plasma Proteins, Jacob J. Fine, Boston.—Plasma proteins containing radioactive sulfur, bromine, and iodine were synthesized for the determination of the degree to which capillary permeability is altered in traumatic shock. Hemorrhagic, burn, and tourniquet shock were studied. The evidence clearly contradicts the theory of a generalized increase in capillary permeability and widespread extravascular loss of plasma. Except in burn and tourniquet shock a local loss of plasma, as such is usually insignificant. While plasma loss is the most significant initiating cause of shock, the irreversibility of the shock state is not due to a progressive decline in plasma volume, but rather, to a progressive deterioration of the peripheral circulatory mechanism, characterized by decreased volume flow and velocity flow through capillaries. The most important factor is the stagnation or trapping of blood in the capillaries. The evidence suggests that this deterioration arises from a chemical or hormonal disturbance induced by damage to tissue function arising from the initial but uncorrected crucial loss of plasma volume and possibly from toxic agents elaborated in traumatized tissues. Treatment designed to move the trapped blood out of the capillaries into the normal moving volume of blood would contribute much to shock therapy.

During the discussion, **A. Blalock,** Baltimore, stated that shock results from a combination of regional loss of blood and plasma, neurogenic influences, and metabolic or toxic factors. The latter factor is a fruitful source in the search of further means of therapy.

Nitrogen Metabolism in Severe Burns, Charles C. Lund, F. H. L. Taylor (by invitation), **Stanley H. Levenson** (by invitation), and **Charles S. Davidson** (by invitation), Boston.—On or before the fifth day of a severe burn, a period of severe anemia and hypoproteinemia begins. There is an excessive, measurable loss of nitrogen in the urine as well as losses of unknown amounts from the surface. The loss of nitrogenous substances is so great that intravenous plasma, albumin, and blood cannot possibly cope with it. Very high protein diets are indicated. Anorexia may interfere with the success of these. In some cases intravenous or oral administration of amino-acids is of vital importance. In one severe case with third degree burn of 50 per cent body area, nitrogen balance studies were made over a period of several weeks. There was a progressive rapid loss with a negative balance resulting in extreme emaciation. Nitrogen balance was reached on an intake of 300 Gm. of protein (or equivalent) per day. Rapid improvement of condition followed, raising this intake to 500 Gm. This is equivalent to ten pounds of meat per day.

Factors Determining the Rational Treatment of Thermal Burns, Allan O. Whipple, New York.—There is a delay in the liberation of thromboplastic substance in burned areas and there is liberated a vasoconstrictor substance with the increase in the permeability of the capillaries in the immediately surrounding areas and an increased flow of lymph. The edema of the tissues in the burned area

encourages infection, the ingrowth of fibroblasts, the necrosis of tissue, and retards epithelization and healing.

Drinker produced thermal burns of both paws of cats simultaneously and immediately applied a pressure dressing to one of them. There resulted no edema, no tissue necrosis, and a much more rapid healing than in the control paw which received no pressure dressing. The evidence at present favors the use of pressure dressings in the local treatment following aseptic means of handling the burned surfaces, the use of sulfonamide drugs in an effort to prevent infection, and the use of plasma in the liberal, indicated quantities to prevent and control burn shock.

Early grafting of surfaces is indicated, grafting suitable parts of the areas between other areas in which necrotic tissue is still present. Dressings should be infrequent and always carried out with the aseptic surgical technique used in the operating room.

Bovine Bone Gelatin as a Plasma Substitute in Hemorrhage and Burn-Shock, John S. Lockwood, W. M. Parkins (by invitation), **C. E. Koop** (by invitation), **C. Riegel** (by invitation), and **H. M. Vars** (by invitation), Philadelphia.—A solution of 6 per cent gelatin in saline solution, with a colloid osmotic pressure higher than plasma, was investigated as a plasma substitute.

Normal dogs tolerate repeated weekly infusions of amounts of gelatin-saline equivalent to 60 per cent of the circulating plasma volume without evidence of toxic reactions specific to the gelatin. Unfavorable reactions that do occur are reversible, and are produced by infusion of comparable amounts of saline or plasma.

About 50 per cent of the gelatin is excreted in the urine within forty-eight hours and most of the remainder may be utilized as a form of available protein.

Because of its capacity to maintain colloid osmotic pressure and blood volume, gelatin is superior to saline in compensating for blood loss in severe hemorrhage.

Gelatin produces pseudoagglutination and more hemodilution than plasma. In experimental burns in animals it was much less effective in controlling burn shock than plasma.

L. S. McKittrick, Boston, briefly reviewed the observations made in the treatment of burned patients received at the Massachusetts General Hospital following the Cocoanut Grove disaster. Factors contributing most to the success were strict isolation, strict surgical aseptic dressings, boric acid ointment pressure dressings of the burned surfaces, infrequent dressings, and sulfadiazine and penicillin administered orally or parentally. Many patients had severe injuries to the trachea as a result of irritating gases. Five required tracheotomy. It was the impression that possible errors in the treatment consisted of the administration of too much salt solution and morphine.

S. L. Koch, Chicago, reviewed his principles of the handling of burns, stressing the necessity of strict surgical asepsis. **R. Elman,** St. Louis, stressed the necessity of maintaining nitrogen balance and the importance of the state of nutrition in the success of grafting. Grafts are less likely to take if the general nutrition is impaired.

M. D. Morrow, M.C., U.S.N., described a method of taking grafts in which the full thickness of skin is excised and the edges which remain are brought together and sutured for primary healing. The excised segment is then entirely freed of fat, and cut into from 100 to 200 small bits of skin which are placed on the granulating surface as pinch grafts.

Improved Diagnosis and Treatment of Ruptured Intervertebral Disks, Walter E. Dandy, Baltimore.—Ruptured lumbar intervertebral disks can always be diagnosed without spinal injections of air or lipiodol or even without lumbar punc-

tures. Almost all are at either the fourth or fifth lumbar nisc. Ninety-five per cent of patients with low back pain and sciatica have herniated discs; 2 per cent are due to spondylolisthesis, 1 per cent to tumors and 2 per cent to congenital deformities of the vertebrae. Anteroposterior and lateral films of the lumbar spine are necessary to rule out these lesions. Reported were the results of operations for herniated discs in 506 cases with only 14 recurrences of symptoms. In 300 cases during the last two years there was no failure to obtain relief and no recurrences.

There are protruding discs and very small (concealed) discs. Both give precisely the same symptoms. The latter will not show in spinal injections of lipiodol and they are one-half the total number.

Localization can usually be made at operation by the increased mobility of the joint determined by pushing the spinous processes.

The entire disc is removed by curettement in order to prevent recurrence.

Spinal fusions are unnecessary and undesirable. Opening and curetting the joint between the articular surfaces promotes fusion.

During the discussion, **G. Horrax,** Boston, stated his opinion that pneumospinal mylography was indicated in doubtful cases and that the examination of the spinal fluid was more or less routinely indicated.

J. A. Key, St. Louis, stated that many cases with a disc syndrome were relieved by nonoperative management and that operation should not be done until the patient asks for it. He questioned that fusion ever resulted from a laminectomy and believed that spinal fusion was frequently indicated as a supplementary procedure.

War Wounds of the Central Nervous System, W. M. Craig, Captain, M.C., U.S.N.R.—The recognition and treatment of shock, the use of the sulfonamides, the improved transportation of the wounded have almost revolutionized the treatment of wounds of the central nervous system. Transfusions of blood, plasma, and albumin administered in sufficient quantities to combat shock have made possible the transportation of patients over long distances. The emergency treatment of open head wounds consisting of shaving the scalp, arrest of hemorrhage, and local application of sulfanilamide has allowed for an interval before reparative surgery is imperative of from thirty-six to forty-eight hours. These two factors have not only lowered the mortality and reduced the incidence of infection but have changed the plan for the care of these cases.

Wounds of the spinal cord still produce marked disability depending upon the severity of the lesion but the factor of infection has been moderated. Spinal shock caused by wounds of the contiguous structures have been noted and under proper treatment have shown a tendency to recovery in a large percentage of cases.

The local application of sulfanilamide to wounds has made possible the earlier repair of injured nerves and does not interfere with nerve regeneration. While at the present time an end-to-end anastomosis is the operation of choice, use of nonabsorbable sutures, fibrin glue, and nerve grafts are being investigated.

Peripheral vasoneuropathy, or the so-called immersion foot, has been recognized as a disabling affection of the extremities occurring to men who have been adrift at sea. Degeneration of the peripheral nerves has been demonstrated in amputated feet and legs associated with pathologic changes in the veins and arteries.

A. W. Adson, Rochester, Minn., in the discussion, emphasized the value of oxygen, plasma and whole blood transfusion, and chemotherapy in the treatment of these cases.

Goeffrey, Jefferson, London, Eng., discussed penetrating wounds of the brain; the use of suction to remove foreign material and damaged tissue, followed by the

topical application of sulfonamides. He stated that these patients were more likely to develop an encephalitis from an infection involving the ventricle than meningitis.

Cerebral Concussion-Alterations in Cerebral Volume, Blood Content, and Histological Changes After Experimental Injury by Acceleration of the Head, James C. White, John R. Brooks (by invitation), **Joel C. Goldthwait** (by invitation), and **Raymond D. Adams** (by invitation), Boston.—Determinations were made of brain volume, vascular congestion, and microscopic changes in cats after varying degrees of concussion. Concussion was produced by striking the cat in the occiput with a heavy steel pendulum. At a striking speed of 34 feet per second, concussion (judged by changes in reflexes, respiration, and cardiac rate) was minimal, whereas at a speed of 48 feet per second occasional linear fractures and death without recovery of respiration might take place. Even in these fatalities there has been no evidence of laceration or gross contusion of the brain, although basilar hemorrhages have been present in a few of these cats. Whereas after decapitation and exsanguination the brain of the normal cat was from 10 to 12 per cent smaller than its surrounding calvarium (differential index of brain volume), in the concussed animal this index might be reduced to between 8 and 5 per cent. Although the actual degree of increase in volume of the exsanguinated brain amounted to a maximum of only 5 per cent, swelling has been uniformly present after concussion, and has varied directly with the observed severity of the concussion in a series of twenty cats. In animals sacrificed at varying periods after concussion the swelling began within fifteen minutes of the blow, reached its maximum at the end of twenty-four hours, and disappeared after seventy-two hours. Microscopic examination revealed many of the changes which have been regarded as indicative of cerebral edema, such as increase in size of pericellular and perivascular spaces, swelling of oligodendroglia, and formation of vacuolar spaces in the white matter. These histologic changes correlated fairly well with the degree of cerebral edema as determined by increased brain volume.

It was their feeling that certain other factors, such as anoxia and hypercapnoia secondary to respiratory obstruction or failure, or extensive contusion of brain substance, are required to explain the elevated intracranial pressure which is often present in cases of severe cerebral injuries in man.

In the discussion, **F. Grant,** Philadelphia, stated that the sudden arrest of the head in motion was likely to cause greater damage to the brain. He sited the above work as evidence against the advisability of routine use of spinal puncture drainage in head injuries.

The Thyrocardiac—A Review of Six Hundred and Thirty Cases, Frank H. Lahey, and **Lewis M. Hurxthal** (by invitation), Boston.—Reviewed were the observations made on six hundred and thirty patients with thyrocardia. The prophylactic removal of toxic adenomas before severe cardiac damage has been produced was emphasized. If the pulse rate and basal metabolic rate remain balanced, cardiac decompensation does not occur. Decompensation occurs in those cases in which pulse rate does not increase proportionately with the basal metabolic rate or in which the pulse rate is excessive in relation to it. Cyclopropane anesthesia has induced ventricular fibrillation. The best anesthesia appears to be induction with ethylene followed by ether in these cases. Quinidine is unnecessary in the treatment of fibrillation. The mortality in this group has shown a progressive decline with the years.

R. S. Dinsmore, Cleveland, in the discussion, expressed his preference for avertin foundation anesthesia supplemented with gas or local infiltration. He also stated that in cases with fibrillation it was desirable to administer digitalis preoperatively and that quinidine should be given if fibrillation continued beyond

the seventh postoperative day. He also stated that about 20 per cent of the toxic cases had at some time fibrillated and that on admission to the clinic 4 per cent were decompensated and 5 per cent fibrillated.

Experiences of a Surgical Consultant to a Service Command, Bradley L. Coley, Col., M.C., U. S. Army.—The activities of a surgical consultant to a service command were reviewed.

The high order of surgery found in most of these hospitals is due to the provision of highly trained personnel, excellent equipment, well-developed surgical teamwork and supervision by well-qualified chiefs of surgical service.

The need for a form of educational program, i.e., postgraduate medical education adapted to Army conditions is recognized and some of the measures taken to fill this need were discussed.

Grover C. Penberthy, Detroit, during the discussion, stated that no previous army had ever received as high quality of medical service and care as the present armed forces. He summarized the numerous ways in which efforts were being made constantly to improve the service.

Note regarding the article entitled "The Therapy of Shock in Experimental Animals With Serum Protein Solutions. II. Fate in the Body of Concentrated and Dilute Serum and Saline Solutions" by E. E. Muirhead, M.D., C. T. Ashworth, M.D., L. A. Kregel, M.D., and J. M. Hill, M.D., Dallas, Texas. Since this paper was submitted for publication, the effects of concentrated plasma on the plasma volume of dogs in the state of severe freezing shock has been once more tested. In this new group of ten dogs the plasma volume determinations for the control period, shock period, and post-therapeutic period were conducted in accordance with the technique recently presented by Longmire and Price (Price, P. B., Longmire, W. P.: Use of T-1824 in Plasma Volume Determinations, Bull. Johns Hopkins Hosp. **71**: 51-83, 1942) i.e., the dye solution was weighed, all injections were made under vision, all samples were corrected for hemoglobin staining using the 540 mm. and 620 mm. filters, and the disappearance curves were established on semilogarithmic paper. The reinjection dye level was established by subtracting the preinjection level rather than resetting the colorimeter at 100. In all of these experiments the plasma volume increment was far greater than the volume of solution injected, indicating a shift of fluids into the blood stream. The amount of plasma protein increment accounted for 86.7 per cent of the total amount of protein injected, indicating a post-therapeutic loss of 13.3 per cent of the injected protein. This feature was not unexpected in view of the over two times greater area of local capillary damage (frozen site) as compared to the extent of capillary damage in the present experiments.

Book Reviews

Orthopedic Subjects (Military surgical manual IV). Prepared and edited by the Subcommittee on Orthopedic Surgery of the Committee on Surgery of the Division of Medical Sciences of the National Research Council, George E. Bennett, Chairman. Philadelphia, 1942, W. B. Saunders Company. $3.

This volume covers four sections titled as follows: Ununited Fractures, Injuries to the Spinal Column, Compound Fractures, and Osteomyelitis.

It is apparent that the book is not a pocket manual to be used for front line work. It deals with more highly specialized phases of orthopedic treatment and was probably meant to be used by the surgeon who wants to familiarize himself in regard to these phases of orthopedic care.

The sections are on the whole well done. The section on ununited fractures presents a rather limited view of the subject and leaves much to be desired in the way of handling of this important problem in military practice. Incidentally, it is doubtful that ununited fractures of the femoral neck deserve ten pages in a volume on military orthopedics.

Much of the chapter on osteomyelitis is devoted to that problem as it relates to children. The author of the chapter states definitely that it was written for publication elsewhere and that he "retained the extensive consideration of acute hematogenous osteomyelitis, which might almost be classed as a disease of childhood and is rarely seen among adults, because this is the foundation on which knowledge of pyogenic infections in bone rests." It covers the subject well, but the problem of osteomyelitis of children is not one to concern military surgeons generally.

Numerous other condiitons are not mentioned. The volume seems to lack much that would be of help to a military surgeon.

The book is well printed and the form seems excellent. The illustrations are good, although again it seems that a much more completely illustrated volume would be more valuable as a military manual.

Principles and Practice of War Surgery. By J. Trueta. Pp. 441, with 144 illustrations. St. Louis, 1943, The C. V. Mosby Company. $6.50.

Trueta's surgical experience in combat zones has fully qualified him to write on the principles of war surgery. In this book he explains in detail his method of treatment, sometimes called the "closed plaster treatment of compound injuries," and discusses the pathologic, bacteriologic, and physiologic fundamentals upon which this method is based. The book is divided into two parts: Pathology of War Wounds and General Care of the Wounded, and Essentials of War Surgery. Wounds of the extremities, fractures, and burns are discussed, but injuries of the head, thorax, and abdomen are not included. Following an introductory chapter on the biological principles of treatment there is an interesting section devoted to the evolution of war surgery from the time of Hippocrates.

The remaining chapters in Part I include a discussion of fundamentals such as infection, the passage of bacteria and their toxins through the body, pyogenic infections of war wounds, gas gangrene, tetanus, shock, traumatic vascular spasm, blood

transfusion, and anesthesia in war time. The author has carefully reviewed the present concept of these subjects and has cautiously selected the parts applicable to war surgery as it must be practiced today. The author's viewpoint is both practical and basically sound. For students and surgeons entering upon war surgery as a new field this is a review of well-chosen principles which they might do well to memorize.

The opening chapter of Part II, The Essentials of Treatment and Organization, is particularly valuable to physicians and surgeons on the home front as well as in combat areas. A veteran surgeon of the Spanish Civil War and of the air raids over England, Trueta advises a radical departure from the "static system of assistance with a distant emergency hospital—the casualty clearing station" as developed during World War I, to the "Three-Point Forward System" based, not upon distances in miles, but upon the time factor. He states, "The main basis of success is to have the wounded patient on the operating table at the earliest possible moment. This is the only factor that counts, and is the objective at which the whole organization should aim." Brief plans of organization for the care of air raid victims and front line casualties are included.

The chapter on antiseptics gives a rational and conservative evaluation of their usefulness and concludes with an interesting discussion on the value of soap as an antiseptic as well as a detergent. In his discussion on chemotherapy, Trueta emphasizes the limitations of the sulfonamides when used locally or systemically. Local implantation of these drugs in selected wounds is grudgingly approved.

A lucid description of the technique of excision of wounds is given and accompanied by informative illustrations. The general conception of drainage is discussed; in addition, the author explains the employment of the plaster splint in contact with the gauze dressing in the wound to absorb and draw out the wound secretions.

Trueta advises the reduction and fixation of fractures by means of traction, applied simultaneously with the plaster. In cases of oblique or comminuted fractures which may not be well retained by this method, he advocates transfixion of the fragments above and below with Kirschner wires or Steinmann pins and incorporation of these in plaster to maintain traction.

Of special interest are the chapters on immobilization and the application of plaster, in which the author explains the advantages and reasons for complete immobilization in plaster and describes the technique of making and applying both bandages and patterns of plaster. The latter is very well illustrated.

Primary and secondary sutures, skin grafting of war wounds, articular wounds and amputations are reviewed briefly. Under the heading of regional surgery, seventy-seven pages are devoted to the details of the author's method for the care of fractures of the extremities, which is graphically illustrated.

The chapter on burns (fourteen pages long) is an unfortunate anticlimax to an otherwise excellent contribution to the treatment of war injuries. It lacks the thoroughness and careful detail with which all other subjects are treated. The author presents a modification of the tannic acid method of treatment which, in the opinion of most surgeons, has been superseded by better methods. The discussion is almost entirely limited to burns of the hands. Although he properly emphasizes the importance of splinting the hand throughout treatment in the best functional position, he fails to make clear the methods of dressing and redressing in such cases.

Trueta's book, like his work, is a real contribution to surgery and that part of the war effort devoted to conserving the lives and limbs of its victims. Students and surgeons concerned with treatment of compound fractures will find it both interesting and helpful and will be grateful for the numerous practical and valuable procedures presented.

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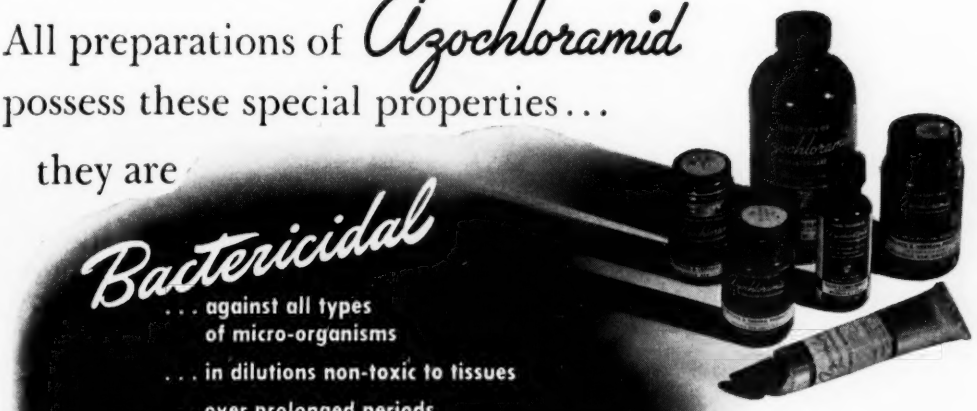

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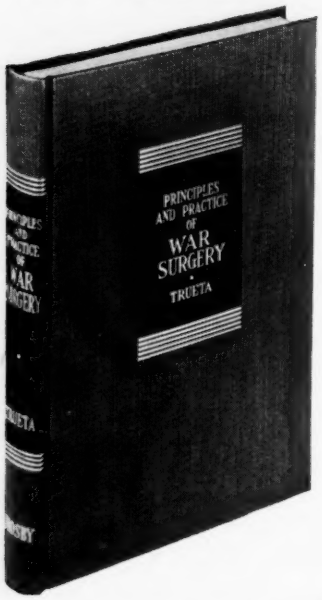

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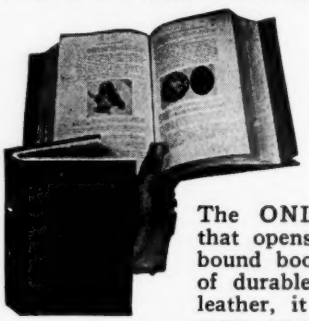

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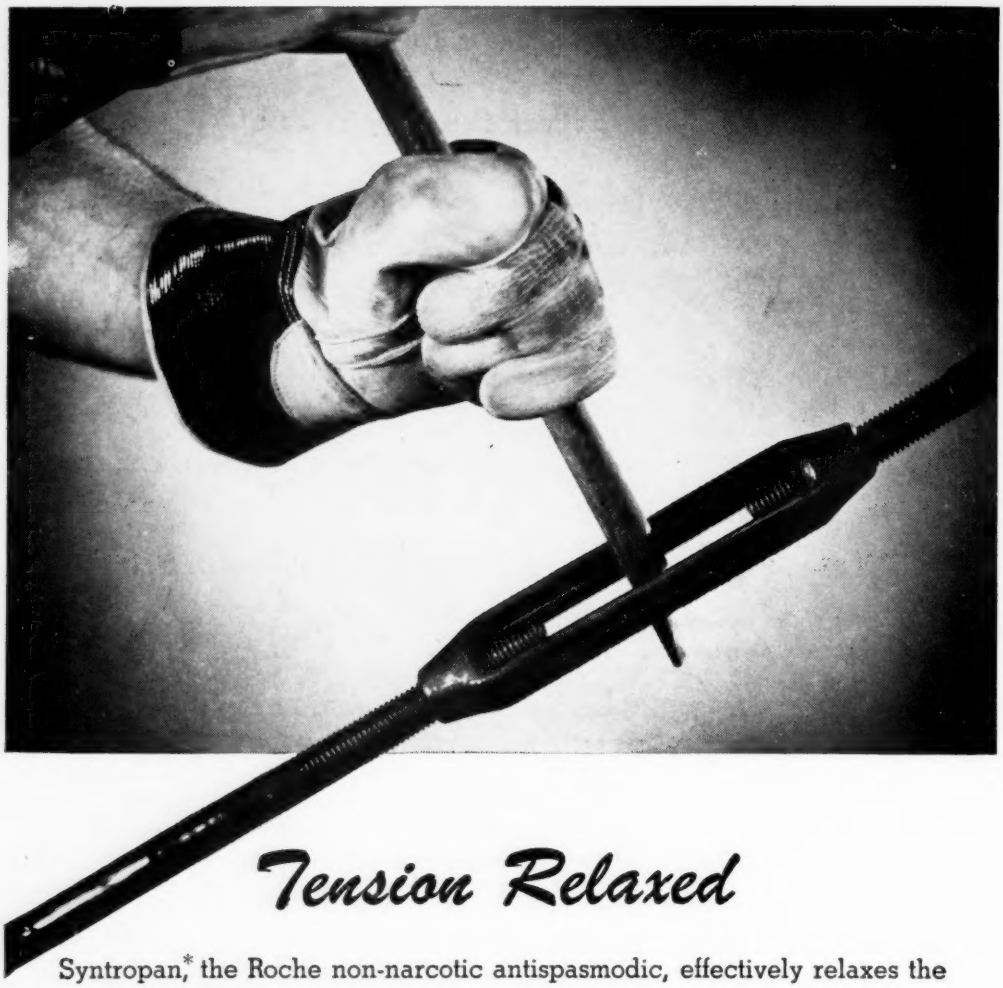

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